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JOURNAL OF DAIRY SCIENCE

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AMERICAN DAIRY SCIENCE ASSOCIATION

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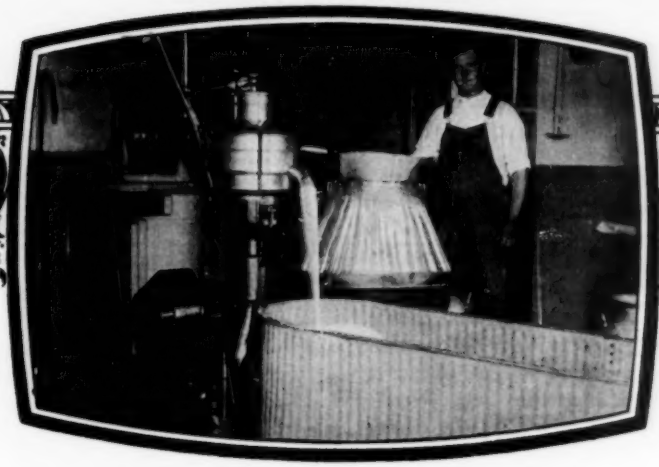

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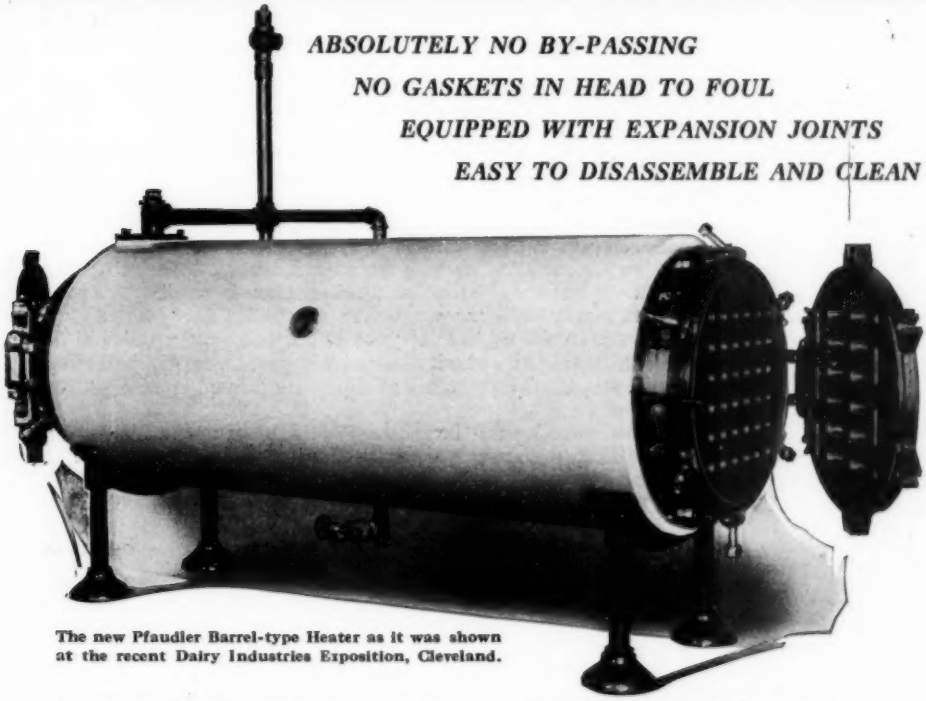

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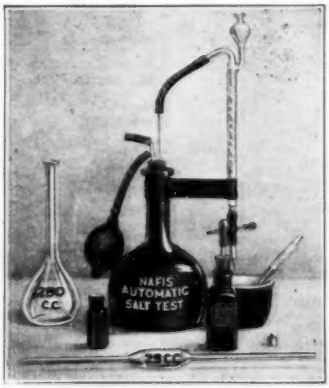

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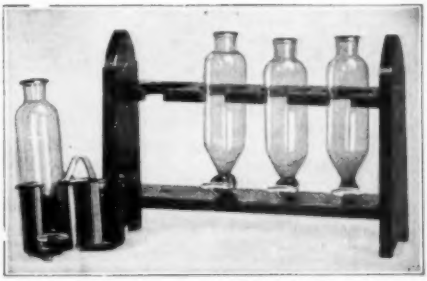

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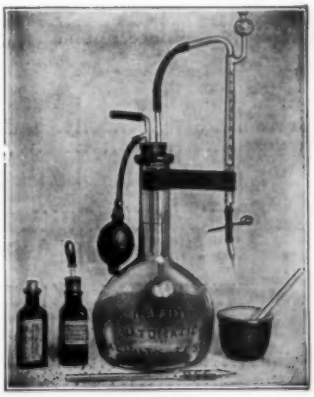

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THE EFFECT OF THE AGES OF SIRE AND DAM ON THE AVERAGE BUTTERFAT PRODUCTION OF OFF-SPRING IN DAIRY CATTLE*

WARREN GIFFORD AND ERWIN C. ELTING

Department of Dairy Husbandry, University of Missouri, Columbia

Since early times many breeders, from their observations of dairy cattle, have concluded that immaturity and senescence of parents have a marked effect upon the milk and butterfat production of the progeny. Considering the economic importance of the effects of these factors upon the dairy industry, there has been a very scant amount of analytical consideration given to determine any variations in the performance records of progeny due to different ages of parents.

It is well known that the age of parents affect fecundity, and birth weights in domesticated animals, and many investigators believe that sex-ratios are also affected by the same influences. Carmichael and Rice (3) in their study of fecundity in swine found that there was a gradual increase in the size of the litter as the sows grew older up to the time they were three years of age, after which the tendency for decrease in litter size became apparent. Jones and Rouse (10) conclude that in multiparous animals the size of the litters and the frequency of production of litters increase with the age of the female to a maximum and then a decline follows. They also give evidence that in general there is an increase of litter size with the increasing age of the male. The observations made on the fecundity of uniparous animals coincide with similar ones on multiparous animals. The conclusions are confirmed by King (11), Marshall (13), Frolich and Georgs (8), Heape (9), Duncan (6) and others.

Donaldson (5) reports that the birth weight of rats increases with the increasing age of the dam. Kopec (12), as cited by the Experiment Station Record, in a statistical study on weights of young and size of litter in rabbits found that the age of dams did

* Received for publication August 1, 1927.

not influence the size of litters or birth weight during the first two years, but that dams three years old produced larger litters and heavier young. Eckles (7) notes that the maturity of the dairy cow has some effect upon weights of calves at time of birth. The average weight of the first born is less than the subsequent calves, and there is a tendency for cows of an advanced age to produce calves rather smaller than those from cows in the prime of life.

Parkes (15), in his studies of mammalian sex-ratios, concludes that there is much contradiction in the results of the many investigations determining the effect of the age of the male upon sex-ratios, but found there was much evidence that young mothers have an excess of males and that the male percentage decreases with the advancing age of the dams.

Redfield (18) as quoted by Marshall (14) published a dynamic theory of development in which he assumed that by exercise a horse acquired "dynamic development" which facilitated speed and which was transmitted to his offspring. His data, collected from the Index Digest for trotting horses, show that the average age of sires of 2:10 trotters was more than nine years at the time they were born. Marshall, in a similar study, believes that the records do not reveal any superiority of old sires over the younger ones.

Chaudhuri (4) studied the relation of the age of the sires and dams of the prize winners in the Shorthorn classes at the Highland and Agricultural Society's Shows and found that with both the sires and dams there was a tendency for a greater number of offspring from immature animals but attributed these tendencies to the fact that young animals are kept in greater numbers by breeders in Scotland for breeding purposes. Allen (1) determined the ages of the sires and dams for cows that made very high and very low seven-day records as reported by Volume 27 of the Advanced Registry year book published by the Holstein-Friesian Association of America and concluded from the study of these extreme quartiles of production that the parentage of the high producing dairy cows is no older than the parentage of comparatively low producing cows.

The amount of data presented in the literature dealing with the relationship of age of parents and quality of offspring are very meager, although from the practical breeding viewpoint it is clearly advantageous to know definitely whether dairy heifers born from immature or aged parents will on the average produce as much butterfat annually as those born from parents during the more active period of maturity. To get more quantitative expressions on this question the writers made a study of the records of Guernsey cows as reported in the Advanced Registery of the American Guernsey Cattle Club, to January 1, 1924, and have determined the relation between the age of the parents and butterfat production in the offspring.

PROCEDURE

Butterfat records, and dates of birth were secured for the daughters of all the sires of the Guernsey breed that have ten or more Advanced Registry daughters, making this special selection of sires because it was believed that the selection made by breeders in discarding inferior bulls would be partially eliminated, and that such a selection would decrease the average production of groups sired by inferior animals that would fall primarily in young groups and not in older ones.

Since it has been pointed out by Pearl and Patterson (17), Pearl, Gowen and Miner (16), and Brody, Ragsdale, and Turner (2), that fat production in dairy cattle gradually increases and decreases in a logarithmic form, rising at an ever decreasing rate until the age of maximum production is reached and then gradually decreasing at an even decreasing rate with the onset of old age, it was deemed necessary to change the records of cows made at different ages to a common age record in order to secure comparative values from all records studied. All records were changed to a mature equivalent record by multiplying the annual fat record by the different age conversion factors given in table 1 as used by Turner (19). The term fat record throughout the remaining discussion will indicate a mature or mature equivalent record. In case a cow had more than one Advanced Registry record, the largest mature equivalent record was used.

When the fat records were determined and the date of birth recorded, the ages of the sires and dams were computed at the time of birth. The fat records were then grouped according to the age of parents at the time the progeny was born as shown in the correlation surfaces (tables 2 and 3). The age intervals include all animals within six months of the age given.

TABLE 1

Age conversion factor for Guernsey cows

AGE	FACTOR
years	
Under 2	
2– 2½	1.313
2½– 3	1.251
3– 3½	1.194
3½– 4	1.142
4– 4½	1.100
4½– 5	1.064
5– 5½	1.041
5½– 6	1.023
6– 6½	1.013
6½– 7	1.006
7– 7½	1.000
7½– 8	1.000
8– 8½	1.004
8½– 9	1.009
9– 9½	1.017
9½–10	1.029
10–10½	1.041
10½–11	1.058
11–11½	1.075
11½–12	1.093
12–12½	1.113
12½–13	1.137
13–13½	1.162
13½–14	1.191
14–14½	1.219

From the same data, all fat records were secured that had been made by the progeny of parents that were of the same age at the time they were mated, in order that any age effect a parent might exert upon the progeny would not be counter-balanced

TABLE 2

Correlation surface for age of Guernsey cows and yearly butterfat production of daughters

CLASS	AGE OF DAMS IN YEARS														TOTAL
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Daughters' yearly fat production in pounds															
375	35	46	38	30	37	17	15	12	4	2	5	3	2	1	247
425	62	81	75	60	48	37	31	21	17	8	4	5	4	5	488
475	74	87	72	84	61	47	37	35	22	16	10	5	4	1	555
525	64	90	105	69	62	52	42	26	15	13	13	6	8	7	572
575	54	66	60	85	62	54	32	26	18	17	13	5	1	3	496
625	42	49	64	60	57	44	30	29	19	13	3	5	5	4	424
675	34	55	43	43	45	43	24	16	12	9	6	2	3	3	338
725	33	34	39	33	22	26	18	9	6	2	7	4	0	0	233
775	12	23	22	21	15	16	9	7	2	5	2	0	1	0	135
825	7	15	5	14	9	8	6	5	4	6	2	1	1	0	83
875	5	7	3	8	10	2	2	2	1	3	0	0	0	2	45
925	1	2	4	6	4	4	1	0	0	0	0	0	0	0	22
975	0	3	2	3	0	1	1	0	0	0	0	0	0	0	10
1025	0	1	1	1	1	0	0	1	2	0	0	0	0	0	7
Total.....	423	559	533	517	433	351	248	189	122	94	65	36	29	26	3,625

TABLE 3

Correlation surface for age of Guernsey sires and yearly butterfat production of daughters

CLASS	AGE OF SIRE IN YEARS														TOTAL
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Daughters' yearly fat productions in pounds															
375	45	78	60	55	20	17	8	8	11	2	5	3	1	0	313
425	65	138	120	89	52	31	23	17	11	5	6	3	0	0	560
475	65	175	130	86	69	27	26	26	19	15	6	2	3	1	651
525	64	153	137	101	63	37	26	24	12	11	4	3	2	2	639
575	61	117	123	76	47	48	30	23	8	5	11	3	1	1	554
625	47	112	107	61	44	44	19	22	12	8	0	6	2	0	484
675	34	79	47	56	33	33	33	18	1	6	2	3	1	1	347
725	31	54	47	23	28	20	18	7	4	2	0	3	3	0	240
775	18	20	27	17	18	11	8	6	6	2	2	1	2	1	139
825	11	17	12	12	7	6	8	4	0	1	1	1	0	0	80
875	5	9	6	6	5	3	4	2	3	1	0	0	0	0	44
925	2	2	4	7	2	1	1	1	0	0	0	0	1	0	21
975	0	3	2	2	2	0	1	0	0	1	0	0	0	0	11
1075	1	0	1	1	2	2	0	0	0	0	0	0	0	0	7
Total.....	449	957	823	592	392	280	205	159	87	61	37	28	16	6	4,090

by the effect of an older or younger age of the other parent. These data are presented in the correlation surface (table 4).

The coefficients of correlation for these three groups of data are presented in table 5.

The coefficients of correlation representing the relationship

TABLE 4

Correlation surface for Guernsey sires and dams of same age and annual butterfat production of daughters

Daughters' yearly butterfat production in pounds	AGE OF BOTH SIRE AND DAM IN YEARS											TOTAL
	2	3	4	5	6	7	8	9	10	11	12	
375	15	18	7	9	3	1	0	0	0	0	0	53
425	22	21	17	11	6	4	2	0	1	0	0	84
475	33	15	19	12	3	0	6	1	0	3	0	92
525	30	20	16	10	4	3	2	0	0	0	0	85
575	23	11	12	6	4	4	3	0	1	0	1	65
625	17	16	12	6	7	3	2	3	0	0	0	65
675	15	11	8	5	5	5	1	0	2	0	0	52
725	13	11	4	4	5	3	1	0	0	0	0	41
775	5	6	2	1	0	1	0	0	0	0	0	15
825	3	2	2	2	0	0	0	0	0	0	0	9
875	0	1	0	2	0	0	0	0	0	0	0	3
925	0	2	1	3	0	0	0	0	0	0	0	6
975	0	1	0	0	0	0	0	0	0	0	0	1
1025	0	0	0	1	0	0	0	0	0	0	0	1
Total.....	176	134	100	72	37	24	17	4	4	3	1	572

TABLE 5

Coefficients of correlation between annual butterfat production of Guernsey cows and age of parents at time of birth

	COEFFICIENT OF CORRELATION
Age of sires and butterfat records of progeny.....	0.070 ±0.010
Age of dams and butterfat records of progeny.....	0.021 ±0.011
Age of sire and dam (same age) and butterfat records of progeny.	0.050 ±0.028

between the annual fat production of these cows and the age of parents at time of birth cannot be considered as significant positive correlations in any of the three groups. The only indication of an increase in annual fat production with age of parents

is in the case of the very slight relationship between the age of the sires and the progeny records.

In order to observe readily any groups of variates by a certain age parents, either sire or dam, that diverge from the average mean of production for the total group, the arithmetical averages were obtained for the different age groups of dams and sires. These results are plotted in figure 1. According to this figure, there is not a significant indication that any particular age of dams have a pronounced effect upon the records of the daughters. There is a tendency, however, for the average records of the

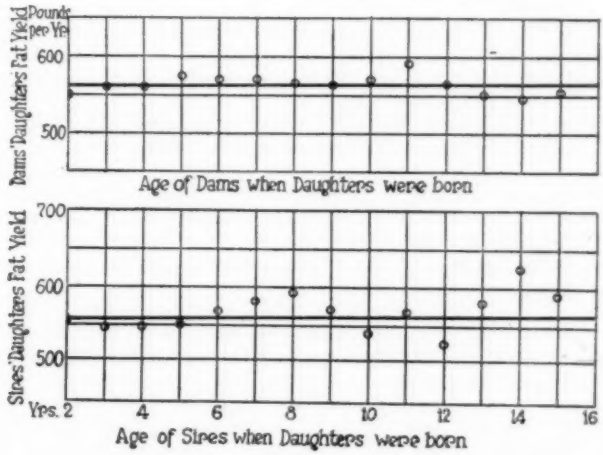

FIG. 1. AVERAGE BUTTERFAT PRODUCTION OF DAUGHTERS OF SIRES AND DAMS AT DIFFERENT AGES

daughters of the sires in the seven and eight-year-old groups to increase, but as the age increases the groups fall around the mean for the entire mass of variates.

The data presented indicate that on the average, the ability of the parent to implant the characters for high butterfat production in its offspring does not increase with maturity nor decrease with senescence. In other words, the age of the sire and dam does not affect the butterfat production of the progeny in the same manner that it does birth weights, fecundity and

sex-ratios in animals. Butterfat production, like sex-ratios and all similar characters, is an inherited character governed by genetic continuity but is not disturbed by any physiological change in the parents' bodies due to immaturity or senescence.

REFERENCES

(1) ALLEN, C. L.: The effect of the age of the sire and dam on the quality of offspring in dairy cows. Jour. Heredity, 1922, xiii.

(2) BRODY, S., RAGSDALE, A. C., AND TURNER, C. W.: The rate of growth and senescence as measured by the rise of milk secretion with age. Jour. Gen. Phys., 1923, vi, no. 1.

(3) CARMICHAEL, W. J., AND RICE, JOHN B.: Variations in farrow. Ill. Bul. 226, 1920.

(4) CHAUDHURI, A. C.: Age and quality of offspring. Jour. Heredity, 1926, xvii.

(5) DONALDSON, H. H.: The rat. Memoirs of the Wistar Inst. Anat. and Biol. No. 6, Philadelphia, 1915.

(6) DUNCAN, J. MATHEWS: Fecundity, Fertility, Sterility and Allied Topics. Adam and Charles Black, Edinburgh, Scotland.

(7) ECKLES, C. H.: Dairy Cattle and Milk Production. The Macmillan Co.

(8) FROLICH AND GEORGS: Fruchtbarkeit und Geschlechtsverhaltnis beim weissen Edelscheim. Jahrbuch fur Wissenschaftliche und praktische. Tiergucht, 6. Jahrg., 1911, Hannover.

(9) HEAPE, H.: Fertility in sheep. Jour. Royal Agricultural Society of England, 3rd Series, 1899.

(10) JONES, S. V. H., AND ROUSE, J. E.: The relation of the age of dam to observed fecundity in domesticated animals. Jour. Dairy Sci., 1920, iii.

(11) KING, HELEN DEAN: The relation of age to fertility in the rat. Anatomical Record, 1916, xi, no. 5.

(12) KOPEC, S.: The influence of certain factors on the weight of the newborn of mammals (Trans. title). (Pam. Paust. Inst. Nauk. Gosp. Wiejak, Pulawach.) (Mem. Inst. Nat'l. Polon, Econ. Rulale Pulawy, 4, 1923.)

(13) MARSHALL, F. H. A.: The Physiology of Reproduction. Longman, Green and Co., 1922.

(14) MARSHALL, F. R.: Age of trotting horse sires. The Amer. Naturalist, 1909, xliii.

(15) PARKES, A. S.: The mammalian sex-ratios. Biological Rev. and Biological Proceedings of the Cambridge Philosophical Society, vol. ii, no. 1, 1926.

(16) PEARL, R., GOWEN, J. W., AND MINER, J. R.: Studies in milk secretion. VII. Me. Agr. Exp. Sta. Bul. 281, 1919.

(17) PEARL, R., AND PATTERSON, S. W.: The change of milk flow with age as determined from seven-day records of Jersey cows. Me. Agr. Exp. Sta. Bul. 262, 1917.

(18) REDFIELD, C. L.: Horse World, February 27, 1906.

(19) TURNER, C. W.: A comparison of Guernsey sires. Mo. Agr. Exp. Sta. Res. Bul. 79, 1925.

THE FREEZING POINT OF CHEDDAR CHEESE: INJURY OF CHEESE BY FREEZING*

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The freezing point of cheese and the injury of cheese by freezing are of vital importance in the determination of freight rates and the adjustment of claims for damage due to freezing. In response to a request for information on this subject for use in connection with a freight rate hearing before the Interstate Commerce Commission a search of the literature was made. No published work could be found on the freezing point of cheese, and the only work found that approached the subject of injury by freezing, was the work by Babcock and Russell (1, 2) on the cold curing of cheese.

Watson and Leighton (3) in response to a similar request, report the freezing point of a Cheddar cheese as −12.9°C. and of a processed Cheddar cheese as −6.9°C, and call attention that the freezing point of the same kind of cheese will vary depending upon the moisture content and degree of ripening.

Babcock and Russell in their study of the cold curing of cheese, stored some Cheddar cheese directly from the press at 15°F., for various lengths of time. They found that cheese stored at 15°F. for seven months had a score of 38 on flavor and 24 on texture. This cheese, however, when subsequently stored at 40°F. increased in score to 42 on flavor and 28 on texture. (In the score card used, 45 on flavor and 30 on texture were perfect.) Cheese stored at 15°F. for five months, then removed to 40°F. for seven months, scored 44 on flavor and 28 on texture. Contrary to the then and still prevailing impression, subjecting the cheese to this low temperature, failed to develop a bitter flavor in the cheese.

Because of the paucity of information to be found on this subject, a limited amount of experimental work was undertaken to

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meet the request. The results of these experiments here reported must be regarded as a preliminary report; more extended experiments on Cheddar and other varieties of cheese are being undertaken.

THE FREEZING POINT OF CHEDDAR CHEESE

Method used

At the outset freezing point determinations were made using thermocouples of copper-constantin junctions. It was soon found that the freezing points of different samples of Cheddar cheese differed widely, and in view of these wide differences and other considerations, an accuracy of 0.1°C. was considered ample. With no greater precision required, and with thermometers of the desired precision readily available, it was decided to use thermometers rather than thermocouples which require vigilant care to obtain trustworthy results.

The thermometer used in this work was a mercury thermometer calibrated to 0.1°C. The bulb of the thermometer was 10 mm. long and tapered from a diameter of 5 mm. at the upper part to 2.5 mm. at the tip. In the first determinations 2-inch cubes of cheese were used. The thermometer bulb was inserted to approximately the center of this cube after a suitable sized hole had been cut with a cork borer. The cube of cheese with the thermometer was placed in the ice cream hardening room which ranged in temperature from −18° to −26°C. Temperature readings of the cheese were made at suitable intervals and recorded.

With the 2-inch cubes of cheese, the typical freezing curve was not obtainable with certainty, in that supercooling usually did not occur. It was thought that this was due to the size of the cube; supercooling and freezing would take place at the surface before the center of the cheeze cube had reached the freezing point; the ice crystals thus formed in the outer parts of the cube would then inoculate the crystallization as the cooling proceeded towards the center, and thus prevent supercooling of the cheese immediately surrounding the thermometer bulb. In order to

obtain a characteristic freezing point curve with greater certainty, it was, therefore, decided to use a 1-inch cube of cheese. No further trouble was then experienced, characteristic supercooling was obtained in all cases where the 1-inch cube was used.

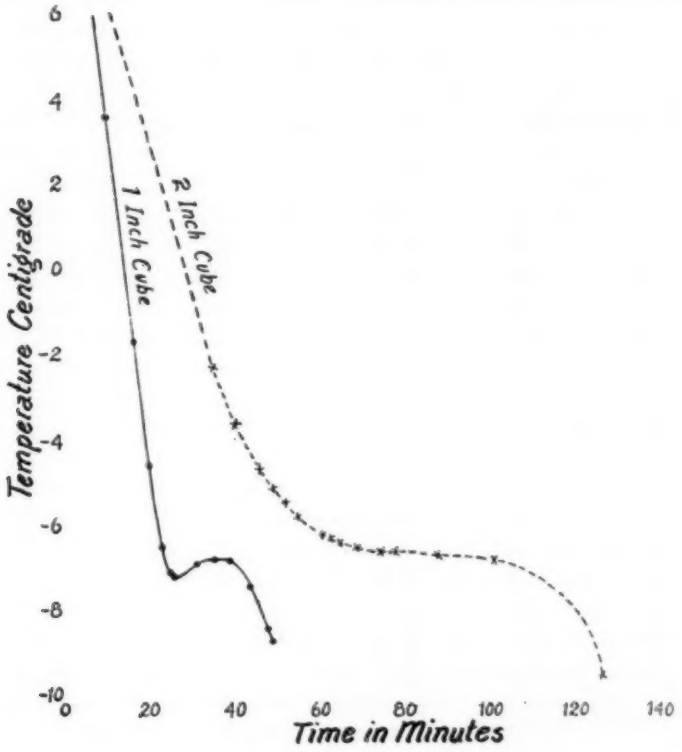


FIG. 1

Figure 1 shows the results obtained with a 1-inch and a 2-inch cube of the same cheese. The highest point to which the temperature rose after supercooling in the 1-inch cube was −6.8°C. In the case of the 2-inch cube there was no supercooling, but the temperature curve indicated that the freezing point was −6.65°C.

(The results in figure 1 correspond to Cheese No. 7 in table 1.) The agreement between these two results is considered close enough to justify the inclusion of the results obtained with the 2-inch cubes. The agreement is a fair indication of the degree of accuracy in the results reported.

TABLE 1

The freezing point of Cheddar cheese

CHEESE NUMBER	AGE OF THE CHEESE DAYS	MOISTURE	SIZE OF CHEESE CUBE USED	TEMPERATURE OF FREEZING ROOM	FREEZING POINT
		per cent		°F.	°C.
1	55		2	0	−5.55
2	35	33.19	2	+6	−5.75
3	76	36.69	2	−4	−6.4
4	23	35.12	2	0	−5.5
				−16	−5.6
5	42	36.37	2	−16	−4.3
6	381	33.77	1	−12	−14.3
7	74	33.41	1	−10	−6.8
			2	−10	−6.65
8	112	36.03	1	−8	−5.62
				−8	−5.50
9	110	35.02	1	−8	−6.15
				−8	−6.40*
10	41	37.10	1	−8	−5.15*
				−8	−4.80
11	39	37.93	1	−8	−5.40*
				−8	−5.15
12	389	32.06	1	+6	−11.3
13	347	33.17	1	+6	−10.8
14	394	32.80	1	+6	−12.9
15	346	33.34	1	+6	−10.9

* Excessive supercooling.

Greater accuracy than the above was considered unnecessary because (1) there is a much wider difference in the freezing points of different samples of the same variety of cheese; (2) the practical application of these results would probably not take cognizance of fractions of a degree; (3) in duplicate determinations on the same cheese wider differences are likely to be found because of non-uniformity of the cheese; (4) in determining the freezing

point of a solid it is useless to strive for the same accuracy that can be attained in the case of liquids because stirring is impossible and it is difficult to control the extent of supercooling.

Results obtained

The results obtained in the work on Cheddar cheese are given in table 1. The size of the cheese cubes used in each case and the temperature of the room in which the freezing took place are given. The age and the moisture content of the cheese are also given because of their relation to the freezing point.

An inspection of this table shows that the freezing points of the Cheddar cheese samples tested ranged from −4.3° to −14.3°C. In seeking the cause for this wide difference, it will be noted that the lowest freezing point was obtained with the cheese that was over a year old. (Sample No. 6 and No. 12 to 15 inclusive, table 1.) The indication is that the age of the cheese, the degree of ripeness, is an important factor in the freezing point.

On the basis of theoretical knowledge, we know that the freezing point of cheese is dependent upon the amount of water present and the amount and character of the substances dissolved in this water. Thus the water content and the salt content of the cheese must be factors that fix the freezing point of cheese. In addition water soluble substances other than salt also must be a factor. It is known that in the cheese ripening, the water soluble substances increase; thus the degree of ripeness of the cheese must also be a factor. The results thus far obtained indicate that this latter factor is of such importance that it overshadows the importance of the moisture and salt content of the cheese within the limits of variation encountered in these samples.

THE INJURY OF CHEESE BY FREEZING

In this preliminary study of the injury of cheese by freezing, a limited number of cheeses were subjected to temperatures well below the freezing point of cheese for various lengths of time. The cheeses were subsequently stored in the cheese curing room to thaw out gradually and were then examined. In the case of six different cheeses the scores of the frozen and unfrozen cheeses

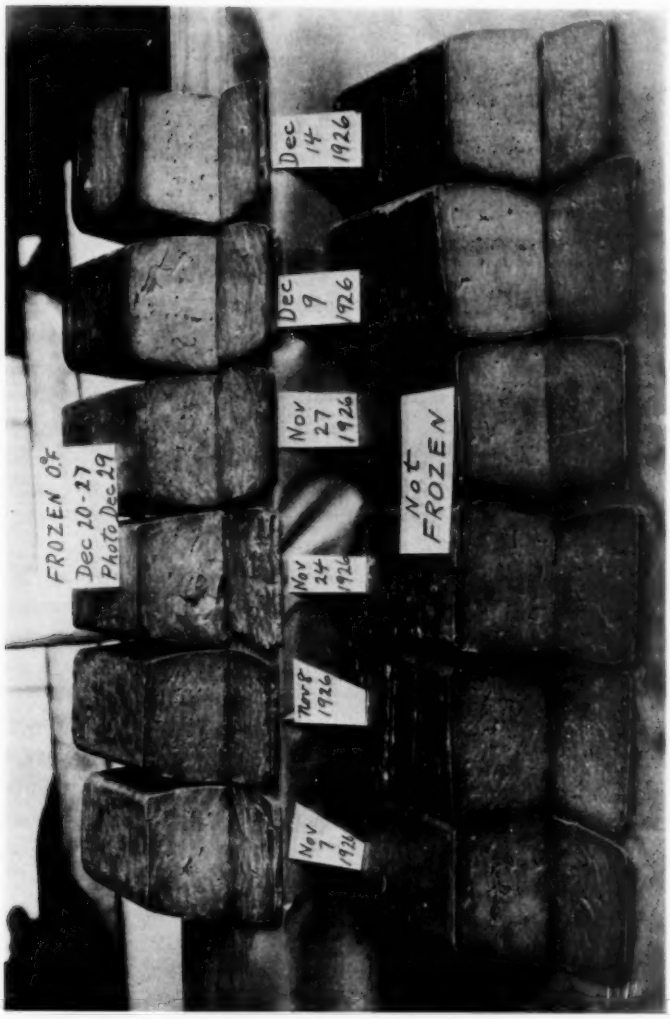
and a photograph showing the appearance of these cheeses, are available. These cheeses had been kept in the ice cream hardening room for seven days, the temperature ranging from 0° to −10°F. Two days after the cheeses had been taken out of the cold room and placed in the cheese curing room to thaw out, they

TABLE 2

The scores for flavor and texture of frozen and unfrozen cheeses

CHEDDAR CHEESE OF	JUDGE NUMBER	SCORE FOR FLAVOR		SCORE FOR TEXTURE	
		Frozen	Unfrozen	Frozen	Unfrozen
November 7	1	24	24	35	36
	2	26	26	36	36
	3	23	24	34	35
November 8	1	24	24	35	36
	2	26	26	35	35
	3	24	24½	36	36
November 24	1	25	25	34	36
	2	26	26	34	34
	3	25½	26	34	35½
November 27	1	23	23	35	36
	2	25	25	34	35
	3	23	23	35	36
December 9	1	25	26	35	36
	2	26	26	36	37
	3	26½	26	34	34½
December 14	1	24	24	36	36
	2	26	26	34	34
	3	27	26	34	35
Average		24.94	25.03	34.79	35.50

were examined and photographed, and a month later they were scored by three cheese judges. In each case a corresponding cheese made from the same vat of milk was used as a control. The results of the scorings are summarized in table 2, and figure 2 is a photograph of these cheeses, showing the appearance of the cut surfaces.


FROZEN 0°F
Dec 10-27
Photo Dec 29
Nov 7 1926
Nov 17 1926
Nov 24 1926
Not FROZEN
Nov 27 1926
Dec 9 1926
Dec 14 1926

It will be noted that the difference in flavor as found by the three judges is so slight as to be negligible. The judges comments are not reproduced here, but it should be noted here that in no case did the judges indicate a bitter flavor in the frozen cheese as compared with the corresponding unfrozen cheese.

The results of the scorings show that the freezing injury is confined primarily to the texture, which becomes more or less crumbly on freezing. Figure 2 records this tendency to crumble in a fairly satisfactory manner. The tendency of freezing to disrupt the texture of the cheese is most evident at the sutures where the curd particles fused together in the pressing of the cheese. Note that the lighter lines at the sutures are decidedly more pronounced in the frozen cheeses than in the corresponding unfrozen cheeses.

Observations made on these six and other cheeses that were frozen showed that in freezing paraffined cheese, the paraffin layer flaked off from the cheese to such an extent that reparaffining would be advisable.

Examination of the frozen cheeses also gave the following additional indications:

1. The damage to the texture by freezing is dependent upon the texture and make-up of the cheese. Cheese in which the sutures were well knit and in which there were few or no mechanical holes, showed less injury to the texture than cheeses not so perfectly made.

2. After the cheeses had been frozen, storing them at normal cheese storage temperatures accomplished a gradual improvement in the texture of the cheese. In some cases this improvement was such that after four weeks it was difficult or practically impossible to distinguish between frozen and the corresponding unfrozen cheese. This recovery in the texture of the cheese observed here is in harmony with the results of Babcock and Russell cited above.

3. After such recovery of the texture, distinction between frozen and unfrozen cheese could be made by observing the manner in which the cheese checked on drying at the surface, the frozen cheese checking more than the corresponding unfrozen cheese.

The above indications were sufficiently evident to warrant their nention here, but they cannot be stated as unqualified conclusions until further substantiated by more extended experiments. In the work planned on the basis of the preliminary results, observations on the various points mentioned in this paper are to be included.

SUMMARY

1. The freezing point of cheese can be determined with sufficient accuracy by the use of a 1-inch cube of cheese and a suitable thermometer.

2. The freezing points found for 15 different Cheddar cheeses ranged from −4.3° to −14.3°C.

3. In addition to the moisture and salt content, the age of the cheese is an important factor in the freezing point.

4. The cheese subjected to freezing showed no perceptible injury to the flavor.

5. Freezing caused the texture of the cheese to be crumbly. The extent of crumbliness developed was dependent upon the texture and make-up of the cheese before freezing.

6. Freezing caused the paraffin to flake off from paraffined cheese.

7. On storage at favorable temperatures after freezing, the cheese texture recovered, in some cases apparently completely.

8. After the texture had recovered, distinction between frozen and unfrozen cheese could be made on the basis of the manner in which the cheese checked on drying at the surface.

The author wishes to acknowledge the interest and assistance in this work by J. L. Sammis, H. L. Templeton, P. E. McNall, A. T. Bruhn, W. Winder, and Math. Michels.

REFERENCES

(1) Babcock, S. M., and Russell, H. L.: Wis. Ag. Exp. Sta. Bul. 94.

(2) Babcock, S. M., and Russell, H. L.: Wis. Ag. Exp. Sta., 18th An. Rep., pp. 136–162.

(3) Watson, Paul D., and Leighton, Alan: Private communication.

A STUDY OF THE YELLOW COCCI WHICH SURVIVE PASTEURIZATION*

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INTRODUCTION

In investigations at the Iowa Agricultural Experiment Station on the bacteria present in various dairy products, the plates frequently showed yellow colonies, sometimes in considerable numbers. Both the surface and subsurface colonies were usually comparatively large and the color quite intense so that they were very conspicuous. These colonies seemed to be especially numerous on plates poured with pasteurized cream or butter made from it, and because they made up such a large part of the flora with these materials a study of the organisms producing them was undertaken. The resistance to heat, the variations that occur and the general action on milk were given the most attention; the results obtained are reported herein.

HISTORICAL

Cocci producing yellow colonies have been isolated by a number of investigators in the study and classification of the organisms in various materials. Certain of these seem to be common in air and water, from which they could easily find their way into milk. Bergey[1] recognized a number of species, some of which have been isolated from dairy products. Various investigations[2] have shown that micrococci producing yellow colonies on agar are rather common among the organisms coming from the interior of the udder.

Marshall[3] isolated a rod shaped organism that produced a

* Received for publication August 19, 1927.

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[1] Manual of Determinative Bacteriology, 2nd edition, 1925.

[2] N. Y. Agr. Expt. Sta., Tech. Bul. 27. 1913.

[3] Mich. State Agr. Col. Expt. Sta., Bul. 147, 1897.

lemon yellow pigment from pasteurized milk but found no cocci among 19 surviving organisms. Russell and Hastings[4] studied the influence of the formation of a surface membrane on the resistance of the organisms in milk and used a micrococcus which retained its vitality at temperatures considerably above those usually used for pasteurization. Conn and Esten[5] found that nearly all of the yellow colony producing bacteria present in milk in the vicinity of Storrs were sarcinae; they state that this group, although nearly always present in small numbers in milk, almost universally disappears after a few hours and never multiplies to any extent. Ayers and Johnson[6] found various types of cocci surviving pasteurization and the same thing has been noted by other investigators. Brannon and Prucha,[7] in studies on the resistance of organisms to pasteurization, worked with a micrococcus which, when it was isolated, was causing counts of a million or more in pasteurized milk. They also found that *Sarcina lutea* was not destroyed by pasteurization.

EXPERIMENTAL

Preliminary observations showed that practically all of the organisms producing yellow colonies on the plates were cocci and accordingly only this morphological type was considered in the studies carried out.

A total of 113 cultures were used, most of which came from dairy products; 51 were from butter made from pasteurized sweet cream, 4 from raw cream, 28 from pasteurized cream, 11 from raw milk, 7 from pasteurized milk, 3 from boiled milk, 1 from starter, 4 from churn rinsings and 4 from air. The numbers of yellow colonies on plates poured with different samples of dairy products varied a great deal, but were commonly large enough so that the organisms very evidently were present in the materials plated and were not the result of air contamination; moreover the plates representing different dilutions showed proportionate num-

[4] Univ. of Wis., Agr. Expt. Sta., 18th An. Rpt., 1901. p. 185.
[5] Storrs Agr. Expt. Sta., 16th An. Rpt., 1904, p. 27.
[6] U. S. Dept. Agr., B. A. I., Bul. 161, 1913.
[7] Jr. Dairy Science, 1927, 10, p. 263.

bers. All of the cultures were purified by plating at least once and often several times.

Resistance of the organisms to heat. In order to establish the ability of the organisms to survive pasteurization exposures, the heat resistance was studied using 12 cultures from various sources and representing somewhat different types. The heating was carried out as follows: Test tubes containing the various materials and stoppered with cotton were put in a large water bath so that the water was well above the surface of the medium and heated to the desired temperature. The tubes were then inoculated, held for thirty minutes and plunged into cold water so that they would cool quickly. In case of question as to whether or not growth had occurred, transfers were made to agar slopes. There was no evidence of a scum at the surface of the material being heated in any of the trials, due undoubtedly to the limiting of evaporation by the cotton stoppers. This method of heating was selected because it was considered to give results more comparable to heating in a vat than would sealed tubes; in a large number of attempts the use of the method resulted in the destruction of various streptococci that were known to be destroyed by pasteurization.

When heated in whole milk all of the cultures grew after an exposure to 70°C. for thirty minutes; 2 of them failed to grow after heating to 75°C. for thirty minutes, while with 2 others the growth was questionable, and after heating to 80°C. for thirty minutes, none of them grew. In lactose bouillon all of the cultures grew after an exposure to 75°C. for thirty minutes while 2 survived 80°C. for thirty minutes. In table cream containing approximately 20 per cent fat, 11 of the cultures survived 70°C., 10 survived 75°C., and 2 survived 80°C., the time being thirty minutes in all cases.

The above results show that the organisms can resist the usual pasteurization exposures, and that, although there were some variations in the resistance of the organisms to heat in the different materials, these were not pronounced. The same general resistance to the usual pasteurization exposures was secured in litmus skimmilk, sucrose bouillon, and ice cream mix.

The influence of the acid content of milk on the heat resistance of the organisms was studied using skimmilk of normal acidity and another portion of the same lot in which *Streptococcus lactis* had produced sufficient acid to cause coagulation. In the normal milk all 12 of the organisms survived 75°C. for thirty minutes, while in the acid milk only one culture survived 65°C. for thirty minutes and all were killed at 70°C. for thirty minutes. In the presence of acid the heat seems to be considerably more destructive than in its absence. Similar results have been obtained in this laboratory in studies on the resistance of *S. lactis* to heat.

The decreased resistance of organisms to pasteurization exposures in the presence of acid is undoubtedly of importance in the pasteurization of sour cream. It may explain in part the greater frequency with which the cocci producing yellow colonies are encountered in plates from sweet cream than from sour cream. It may also account for the higher bacterial efficiencies obtained in the pasteurization of sour cream, although the comparatively low heat resistance of many of the *S. lactis* organisms, which make up most of the flora, is a factor here also.

GENERAL DESCRIPTION OF THE ORGANISMS STUDIED

The colonies of the yellow cocci on whey agar plates were first of a pale yellow color which later deepened to a lemon or sulphur yellow. To the naked eye the surface colonies appeared round, slightly raised, entire, and glistening and under the low power of the microscope they were granular with an entire edge. In microscopic preparations the cells were spherical, of medium size, and arranged singly, in pairs, in tetrads or sometimes in packets. The organisms took the ordinary stains quite readily and were gram positive although gram negative cells were not uncommon, especially in old cultures. They grew well in liquid or on solid media, but brought about changes in milk only very slowly. Gelatine liquefaction and milk digestion occurred with some of the cultures. Acid production in milk and bouillons, when it took place at all, was slight. Growth was best under aerobic conditions, and was rapid at both 21° and 37°C.

DIVISION OF THE ORGANISMS STUDIED

Various characters, especially the morphology, the liquefaction of gelatin, the action on litmus milk, and the growth on slopes suggested a division into three types—A, B, and C.

Distinguishing features of Type A. Type A may be characterized as follows: It was a fairly large coccus, usually arranged in tetrads, and under favorable conditions in packets. It grew well at both room temperature and 37°C. Litmus milk did not materially change in appearance except for a whitish-yellow precipitate in the bottoms of the tubes. Gelatine was slowly liquefied. Growth on whey agar slopes was filiform, smooth edged, slightly raised, opaque, and of a distinct lemon color.

Distinguishing features of Type B. Type B may be characterized as follows: It was a medium sized coccus, occurring singly, in pairs, or in tetrads. The organisms first reddened litmus milk and reduced it and then coagulated and slowly digested it. Gelatine was liquefied very slowly. The growth on whey agar slopes was filiform, opaque, slightly raised, and of a lemon yellow color.

Distinguishing features of Type C. Type C may be characterized as follows: The cells were arranged singly or in pairs and there was considerable variation in size. Acid was produced slowly in litmus milk, and gelatine was rarely liquefied. The growth on whey agar slopes was filiform, opaque, raised, glistening and from a pale to a lemon yellow color.

The descriptions of the yellow cocci that have been published do not afford a clear cut classification of the organisms that were studied. This is partly due to the fact that there are differences in the descriptions of the same organism by different authors. A consideration of the various classifications studied, especially those of Bergey and Hucker[8] suggest that Type A should be considered as *Sarcina lutea*, Type B as *Micrococcus varians*, and type C as *Micrococcus luteus*.

The important point seems to be that there are variations in the heat resistant yellow cocci that are found so regularly in dairy products, especially those subjected to pasteurization.

[8] N. Y. Agr. Exp. Sta., Tech. Bul. 102, 1924.

Apparently resistance to heat is a rather common character of a group of organisms that also has the general property of producing yellow colonies.

GENERAL ACTION OF ORGANISMS IN MILK

The organisms brought about various types of changes in milk but these occurred comparatively slowly so that these organisms are probably of little importance from the standpoint of deterioration of milk or cream under practical conditions. The comparative resistance of the organisms to unfavorable conditions is illustrated by the growth on transfer of agar cultures that had been held nine months in a cooler at from 0° to 10°C. and is also evident from their presence in air. It would accordingly be expected that the yellow cocci might persist in various materials, including dairy products, for extended periods.

SUMMARY AND CONCLUSIONS

On plates poured with dairy products, especially those that had been subjected to heat, there were often yellow colonies of cocci. In general these organisms resisted the usual pasteurization exposures for market milk; they were resistant in skimmilk, whole milk, cream, bouillon and ice cream mix. The organisms were less resistant in milk containing sufficient acid to cause coagulation than in normal milk.

The yellow cocci found in dairy products were of several types. They produced changes in milk or cream only slowly and accordingly are probably of little practical importance in the deterioration of these products.

STUDIES IN THE NORMAL DEPOSITIONS OF MINERALS IN THE BONES OF DAIRY CALVES*

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The optimum development of the animal skeleton is of prime importance to the livestock man. Mineral matter comprises from 3 to 6 per cent of the animal body, about four-fifths of which is found in the skeletal frame-work. In the dairy research field much work has been done concerning the mineral requirements of mature lactating animals, but little has been reported regarding the requirements of growing animals.

Experimental studies with rats have shown that several factors including, proper amounts of calcium, phosphorus, and vitamin D, are necessary to prevent rickets and insure optimum skeletal development.

Although rickets do not appear to be common in cattle, we find considerable evidence on record that mineral deficiencies do interfere with growth and skeletal development as found in laboratory animals. A few of the outstanding references in support of this statement are as follows: Theiler and associates (13) in studying the causes of the diseases "Stijfziekte" and "Lamziekte" in South African cattle found that the addition of bone meal or other phosphorus carriers to the native rations (low in phosphorus) caused a better utilization of food and a much larger increase in body weight per unit of food consumed. Stewart (12) reports the occurrence of rickets in Australian cattle, and it appears that the disease "Stallmangel" reported by Lotsch (9) in Germany was really a form of rickets. Cases of bone disease in calves due to lack or proper utilization of minerals

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have been produced experimentally by Eckles and Swett (5), and Bechdel, Eckles, and Palmer (1).

Recently, Eckles, Becker, and Palmer (6), in reporting on rather extensive investigations on a mineral deficiency in the rations of cattle in parts of Minnesota, have shown that the skeletal development may be seriously affected by a deficiency of phosphorus in the ration. These authors, in an exhaustive search of the literature, have brought forth evidence of mineral deficiencies in the rations of cattle in many localities in the United States including, Montana, Minnesota, the coastal plain of Texas, and in the irrigated sections of the southwest and intermountain country. It is also reported in sections of the east, including eastern Michigan, and the higher altitudes of New York, Pennsylvania, West Virginia, Virginia, South Carolina, Alabama, and Mississippi, as well as many other parts of the world.

It is evident that bone diseases are not uncommon among dairy cattle. The existence of many dairy animals with an undersized skeletal development, suggests the probability of improper mineral feeding to obtain optimum body growth. Little is known concerning the amounts of calcium, phosphorus, vitamin D, or light required by the growing dairy calf. It is also entirely possible that other factors yet unknown play a part in this skeletal development. Furthermore, the most economical sources of the above factors present many problems yet unsolved.

Any satisfactory study of skeletal development requires a close examination of the structure and composition of the bones. Microscopic and x-ray examinations have proven very helpful, but the chemical composition also has been found essential for complete and thorough study. A search of the literature failed to reveal any systematic information as to the normal composition of the bones of calves at various ages. Although the main object of the present study was to make a contribution to the establishment of data on the normal composition of the bones of calves at various ages, it was also our aim to study the adaptation of technique used on such work with small animals.

EXPERIMENTAL

Seven grade Holstein male calves were used as experimental subjects. They were purchased from farmers as bob-veals, when three to four days old. Although the individuals were not as uniform as one might desire for this type of work, the group was a fair representation of normal farm animals. The calves were kept in a box stall about 15 feet by 30 feet in size. It was equipped with individual stanchions, in which the animals were fastened at feeding time. The feeding schedule given by Eckles (7) for skimmilk calves was closely followed. The calves were started on whole milk which was gradually replaced by skimmilk beginning at two weeks of age. Skimmilk was fed during the entire experimental period. This was supplemented with alfalfa hay and a calf grain mixture. The calves were slaughtered at the college meat shop. One was killed at each of the following ages: 60 days, 90 days, 120 days, 150 days, while three were killed at the age of 180 days. The data on the weights of the calves at the time of slaughter are reported in table 1.

TABLE 1

Weights of calves at slaughter, normal weight, and percentage of normal calves

ANIMAL NUMBER	AGE WHEN SLAUGHTERED	LIVE WEIGHT	NORMAL WEIGHT	PER CENT NORMAL
	days	*pounds*	*pounds*	
1	60	135	157	86.0
2	90	145	200	72.5
3	120	302	249	121.3
4	150	340	302	112.6
5	180	304	349	87.1
6	180	417	349	119.5
7	180	449	349	128.7

The normal weights in the above table represent the data of Eckles and associates (8) and are for Holstein females. The small size of calves 1 and 5 may be partially accounted for in that their dams were heifers, while calf 2 contracted a bad case of pneumonia while young, but had recovered at the time of slaughter.

Bones for analysis were removed from the carcasses very shortly after they had cooled. The following were selected for study: the femurs, the humeri, the fifth, sixth, and seventh pairs of ribs and a portion of the frontal bone. The humeri and femurs

TABLE 2

Animal 1. Age 60 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	cc.		per cent	per cent	per cent	per cent	
Frontal	24	16	1.5000	33.41	2.52	39.61	26.98	61.82
Left ribs	95	71	1.3380	47.63	2.62	29.32	23.05	58.82
Left femur	473	390.5	1.2113	54.97	8.62	20.15	24.88	55.19
Left humerus	314	256.5	1.2242	55.04	7.27	21.28	23.68	56.46
Right ribs	91	67	1.3582	35.62	1.47	38.25	26.13	60.79
Right femur	461	379.5	1.2148	32.33	6.93	39.15	28.52	64.46
Right humerus	293	239	1.2259	35.70	7.02	36.92	27.38	64.46

TABLE 3

Animal 2. Age 90 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	cc.		per cent	per cent	per cent	per cent	
Frontal	45	32	1.4063	41.20	2.04	32.13	26.67	56.65
Left ribs	105	79	1.3291	44.88	2.84	29.22	25.90	55.89
Left femur	491	407	1.2064	39.08	7.95	19.89	41.13	37.55
Left humerus	348	286	1.2168	40.17	8.48	21.06	38.77	41.01
Right ribs	109	84	1.2976	34.54	1.42	38.03	27.43	59.38
Right femur	487	402	1.2114	24.18	4.47	39.26	36.36	55.02
Right humerus	360	296	1.2162	26.47	5.18	37.41	36.12	54.73

were taken as typical examples of the long bones. These bones are also the ones commonly studied in other animals, particularly in rats. Ribs were selected because it has been shown that they are among the first to be affected in rickets. A part of the frontal was selected as an example of a membrane bone.

Immediately after removal from the carcass the bones were scraped clean of adhering tissue. They were then weighed as green bone and also weighed by suspension in water. From this data the volume and specific gravity of the bones were calculated.

TABLE 4

Animal 3. Age 120 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	*cc.*		*per cent*	*per cent*	*per cent*	*per cent*	
Frontal	49	31	1.5806	35.91	1.60	37.63	26.46	60.22
Left ribs	208	154	1.3506	44.81	3.90	29.01	26.18	56.56
Left femur	863	699	1.2346	40.47	10.38	23.24	36.29	47.28
Left humerus	608	491	1.2383	41.28	13.81	26.03	32.69	57.96
Right ribs	210	155	1.3548	35.66	2.37	37.60	26.74	60.67
Right femur	848	684	1.2398	17.32	7.57	49.97	32.71	66.53
Right humerus	627	508	1.2343	18.59	9.00	44.65	36.66	61.75

TABLE 5

Animal 4. Age 150 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	*cc.*		*per cent*	*per cent*	*per cent*	*per cent*	
Frontal	49	35	1.4000	34.88	2.69	37.25	27.87	59.66
Left ribs	275	205	1.3415	43.85	3.57	29.50	26.65	56.10
Left femur	935	746	1.2534	37.04	21.27	24.57	38.39	58.93
Left humerus	686	546	1.2564	38.49	18.75	25.31	36.20	59.19
Right ribs	275	199	1.3819	36.12	2.10	37.09	26.79	60.04
Right femur	923	735	1.2558	22.46	12.38	44.34	33.20	68.05
Right humerus	667	527	1.2657	23.20	10.45	44.97	32.73	67.78

In order to study the advisability of sampling, the entire bones from the left side of the animal were saved for analysis, while those from the right side were sampled by retaining about one-third from the middle of the ribs and a cross-section about an

inch long from the middle of the humerus and femur. The whole bones and portions were partially dried in a warming closet at 50°C. to facilitate grinding. The loss of moisture was then determined, and grinding was carried out immediately with a

TABLE 6

Animal 5. Age 180 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	*cc.*		*per cent*	*per cent*	*per cent*	*per cent*	
Frontal	81	56	1.4464	36.63	2.01	35.64	27.73	58.08
Left ribs	222	159	1.3962	39.79	3.71	33.48	26.73	59.26
Left femur	850	679	1.2518	38.70	19.21	24.89	36.41	59.14
Left humerus	606	480	1.2625	39.79	15.18	25.13	35.08	55.81
Right ribs	215	152	1.4145	30.52	1.75	42.21	27.27	62.32
Right femur	863	685	1.2599	17.69	8.56	50.84	32.37	68.94
Right humerus	586	461	1.2711	17.18	8.79	50.36	32.46	68.03

TABLE 7

Animal 6. Age 180 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	*cc.*		*per cent*	*per cent*	*per cent*	*per cent*	
Frontal	101	67	1.5075	33.16	1.82	38.00	28.84	58.44
Left ribs	324	237	1.3671	40.67	3.37	32.41	26.92	57.92
Left femur	1,240	984	1.2602	36.67	21.22	24.40	38.93	57.94
Left humerus	900	708	1.2712	38.40	16.06	24.98	36.62	54.85
Right ribs	313	225	1.3911	32.32	2.48	39.02	28.66	59.85
Right femur	1,223	971	1.2595	21.75	12.07	44.35	33.90	67.01
Right humerus	896	703	1.2745	21.34	9.90	47.01	31.65	68.37

poultry-bone grinder. Samples were weighed out in triplicate in porcelain crucibles. They were dried to constant weight in a vacuum oven at 80°C. with 15 pounds vacuum. About four hours of drying proved satisfactory for this process.

The dry samples were then quantitatively transferred to fat extraction thimbles. They were extracted for forty hours with hot alcohol by a continuous redistillation process. They were then returned to the original crucibles and dried to constant weight and the amount of fat calculated. The moisture and fat free samples were then ashed in an electric muffle furnace for twenty-four hours.

The ash was now transferred to a 250 cc. volumetric flask, dissolved in 10 cc. of concentrated HCl and made up to volume. Calcium and phosphorus determinations were made from this

TABLE 8

Animal 7. Age 180 days

BONE USED	WEIGHT	VOLUME	SPECIFIC GRAVITY	GREEN BONE				ASH AS PERCENTAGE OF FAT AND MOISTURE-FREE BONE
				Water	Fat	Ash	Organic	
	grams	*cc.*		*per cent*	*per cent*	*per cent*	*per cent*	
Frontal	58	41	1.4146	38.02	2.82	35.98	26.00	60.82
Left ribs	373	270	1.3815	40.00	6.44	31.44	28.56	58.70
Left femur	1,316	1,044	1.2605	32.00	25.93	24.75	43.25	58.83
Left humerus	894	699	1.2790	32.79	23.15	25.60	41.61	58.10
Right ribs	355	257	1.3813	29.13	5.37	39.75	31.12	60.69
Right femur	1,301	1,030	1.2631	21.10	17.28	42.52	36.38	69.00
Right humerus	885	692	1.2789	20.02	15.51	44.40	35.58	68.87

solution. The phosphorus was determined volumetrically by the official method of the Association of Official Agricultural Chemists (11). For determination of calcium the McCrudden (10) method was used.

The results of analyses are given in tables 2 to 8. Phosphorus and calcium showed such slight variation between samples that it is deemed unnecessary to report them all. The lowest percentage of phosphorus obtained was 17.90 per cent of the ash while the highest was 18.77 per cent. For calcium the extreme figures were 36.80 to 39.14 per cent of bone ash.

DISCUSSION

The weights of the frontal bone samples are not consistent with the size of animal as only a portion of the frontal bone was removed. This portion was approximately $1\frac{1}{2}$ by $2\frac{1}{2}$ inches in size but varied some for the different animals. The rib weights are always the totals of the three ribs used.

The data on the weights and volumes of the bones from both the right and left halves of the body are for the entire bones. The analytical data, however, are from samples taken from the entire bones of the left side, and from portions of the bones from the right side, as stated above.

The percentages of water in green bone show that the frontal is the lowest in this constituent, followed in order by the ribs, femur, and humerus. As might be expected, the total bones contain a higher percentage of moisture than portions from the center of the bones. Another noticeable fact is the decrease in the percentage of water as the age of the animals increases.

As the fat determinations were made by calculations of loss of weight by extraction, they are not as accurate as might have been obtained by using regular ether extraction methods. But these figures will give comparative fat content and show the long bones to be the higher in this constituent.

The ash percentage shows just the reverse of the picture portrayed by the water percentages, ash being highest in the frontal followed by the ribs with the long bones lowest. As growth takes place in the ends of the bones the higher ash percentages in the central section are quite logical. The percentage of ash in bone increases somewhat with the age of the animals.

The percentages of organic matter were obtained by subtracting the sum of the ash and water percentages from 100. In general, these figures are quite uniform. A high fat content seems to indicate a high percentage of organic matter.

The last column in the tables gives the percentage of ash in the bones based on a fat and moisture free basis. These are the data most used in small animal work and seem to indicate best the condition of bone. Dutcher, Creighton, and Rothrock

(4) found that the femurs of normal rats at six weeks of age contained 62 per cent ash, while the corresponding figure for rachitic animals was 26 per cent. The percentage of ash in moisture and fat free bone probably indicates that the frontal bone is calcified at an early age. It also shows a higher degree of calcification in the center portion of the bone than in the total bone. For studies of bone development, it would, therefore, appear advisable to use the whole bone for analyses as this would include the actively growing portions at the epiphyses and would consequently show up a deficiency more clearly. It is possible that a thin longitudinal slice from the entire length of the bone

TABLE 9

Grams ash per cubic centimeter of bone volume

ANIMAL NUMBER	AGE	FRONTAL	LEFT RIBS	LEFT FEMUR	LEFT HUMERUS
	days				
1	60	0.2641	0.2191	0.1663	0.1738
2	90	0.2285	0.2198	0.1649	0.1731
3	120	0.2381	0.2148	0.1882	0.2102
4	150	0.2661	0.2199	0.1960	0.2014
5	180	0.2464	0.2398	0.1988	0.1990
6	180	0.2686	0.2371	0.1936	0.1977
7	180	0.2456	0.2316	0.1996	0.2048

would prove as satisfactory as the whole bone. We regret that we have no data on this method of sampling.

Another interesting way to indicate the degree of calcification of bones is by the ash per cc. bone volume. These calculations could only be made where the whole bones were used as the volume of cross-section portions used for samples from the middle of the bones was not determined. These data are given in table 9.

Chick and Roscoe (2) have developed a rachitic index by using an A/R ratio. A indicates ash as per cent of fresh bone and R organic residue in fresh bone determined by subtracting the ash, fat, and water percentages from 100. This ratio is about 1:5 for normal animals and drops to 1:1 or 1:2 for rachitic animals. The above data were obtained from rats. If such a ratio were applied to the data in this work it would hold quite well for the frontal bone and the middle portions of the long

bones, but would be much lower if the entire long bones were considered. If more data become available on the composition of bones from calf skeletons such a ratio for normal animals at various ages might be worked into a convenient index for determining bone condition.

As was stated above, the percentage of calcium and phosphorus in the ash of the bones analyzed varied but sightly. Roughly, it was in the proportion of 2 to 1 for Ca and P. It is doubtful if these determinations will be of much value in the study of bone abnormalities, as the percentage of these elements in bone ash probably would not vary much even under abnormal conditions. The work of Chick, Korencheusky, and Roscoe (3), with deficient diets in rats, substantiates this view.

In the introductory statement the dearth of information on the composition of the normal bones of calves was emphasized. It is very evident that such data must be provided before constructive studies on abnormal bones can be made. Once normal data have been established, rachitic rations and other conditions that effect growth and bone development can be advantageously studied. It is appreciated that the data here presented are very meagre, but they at least represent a beginning and it is hoped that further normal data will be contributed by other investigators in this important field.

SUMMARY

The composition of the frontal, ribs, femurs, and humeri of seven normal male Holstein calves are presented. These calves were 60, 90, 120, 150, and three of 180 days of age. The analyses indicate that the ribs, femurs, and humeri are suitable for the study of mineral deposition in the bones of calves. Because of early calcification a section of the frontal bone is of less value. The complete bones give a truer picture of mineral deposition than a cross section portion of them. The percentage of ash based on fat and moisture-free bone and ash per cubic centimeter of bone volume proved to be the most valuable data. The ratio of ash in fresh bone to organic residue may also give a useful index of bone condition.

The percentage of phosphorus and calcium in bone ash is nearly constant and varies only slightly with the age of the animal. The percentage of water decreases with age, while the ash and organic matter percentages increase with the age of the animal. The ash replaces the greater part of the decrease in the water percentage.

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REFERENCES

(1) Bechdel, S. I., Eckles, C. H., and Palmer, L. S. 1926 The vitamine B requirement of the calf. Jour. Dairy Sci., ix, no. 5, 414.

(2) Chick, Harriette, and Roscoe, Margaret Honora 1926 The antirachitic value of fresh spinach. Biochem. Jour., xx, 137–152.

(3) Chick, Harriette, Korencheusky, Vladimir, and Roscoe, Margaret Honora 1926 Biochem. Jour., xx, 622–631.

(4) Dutcher, R. A., Creighton, Mattie, and Rothrock, H. A. 1925 Vitamin studies. IX. Inorganic blood phosphorus and bone ash in rats fed on normal rachitic and irradiated rachitic diets. Jour. Biol. Chem., lxvi, 401–407.

(5) Eckles, C. H., and Swett, W. W. 1918 Some factors influencing the growth of dairy heifers. Res. Bulletin 31, Mo. Experiment, pp. 3–56.

(6) Eckles, C. H., Becker, R. B., and Palmer, L. S. 1926. A mineral deficiency in the rations of cattle. Bulletin 329, Minn. Expt. Station.

(7) Eckles, C. H. 1923 Dairy Cattle and Milk Production. The MacMillan Company, New York., rev. ed., p. 253.

(8) Eckles, C. H. 1920 The normal growth of dairy cattle. Res. Bul. No. 36, Mo. Expt. Station.

(9) Lotsch, E. 1912 Über den Stallmangel, eine Eignartige Rendererkrankung in Sachischen Erzgebirge. Zur Kenntnis des Mineralstoff Wechsels. Z. F. Inf. U. Hyg. D. Hanstiere, 12–205.

(10) McCrudden, Frances H. 1910 The quantitative separation of calcium and magnesium in the presence of phosphates. Jour. Biol. Chem., vii, 83–100.

(11) "Official and Tentative Methods of Analysis" of the Association of Official Agricultural Chemists, published by the Association of Official Agricultural Chemists, Washington, D. C., 2nd ed., 1924, p. 3.

(12) Stewart, A. 1899 A report on the disease affecting cattle in the Moringa District. New South Wales Agr. Jour.

(13) Theiler, A. 1912 Facts and theories about Stijfziekts and Lamziekte. Agr. Jour. Union of S. Africa.

Theiler, A., Green, H. H., and Dutoit, P. J. 1924 Phosphorus in the live stock industry. Agr. Jour. Union of S. Africa, Reprint No. 18.

THE FIRST COURSES IN DAIRY HUSBANDRY*

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Knowledge is the great uplifting force in a civilized world. Its acquisition is, therefore, of supreme importance to human beings. Since knowledge is so all embracing, it would be comparatively useless, were it not arranged, and catalogued in an orderly manner. The organization of knowledge as well as the discovery of new facts has kept and will keep scientists busy. But in order that new generations may acquire the learning and experience of the past, teachers are needed. The teacher is one, who from the vast field of knowledge, takes such facts as will usefully develop the mind of the student and arranges and presents them in such a manner as not only to impart information but to stimulate thought. The teacher, therefore, whether of the kindergarten or the college, has not only a wonderful opportunity but a great responsibility. It is no easy task, but one requiring the greatest thought and effort.

The teacher in the college is a little likely to take teaching less seriously than is his co-worker in the secondary school. This lack of seriousness has been fostered unwittingly by the emphasis of college authorities, upon scholarship, research, and advanced degrees. There has been an all too prevalent feeling in collegiate circles that a learned man must necessarily be a good teacher. The logical deduction from this has been that there must be no suggestion that a learned man could not impart his knowledge satisfactorily to others. Unfortunately, learning does not indicate teaching ability, and the result has been that upon our faculties there have been educated fools.

An educational assumption that has frequently led to poor

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instruction, is, that the collegiate student is of mature mind. Probably this belief has descended from the ancient universities where the students were older and of more maturity. Today, however, students frequently enter college at sixteen and the average age of students is not twenty-one. In most instances also, there are many features that disturb the studious atmosphere of a college and attract and distract the student. It must therefore be borne in mind that the interest of the student must be stimulated and maintained, and that he is still a youth—as he was in high school.

In the modern world there is little time for, or little interest in, on the part of the average student, anything that does not have a practical and useful application. Today there are so many facts that at best one can master but a limited few along some few lines of endeavor. Care must be taken, therefore, not to waste the students' time with useless facts.

The first course in dairy husbandry must be carefully considered from the angles of subject matter, and the manner of presentation. It is assumed that not more than one course in dairying is required so that most students will have only this course. Consequently, the whole field of dairying will have its only presentation through this course.

SUBJECT MATTER

The material that is to go into the course is of vital importance and it must be weighed and considered from various angles as follows:

1. *Previous training of the student.* With the growth in numbers of Smith-Hughes Agricultural high schools, there are beginning to be taught some of the subjects that have been commonly dealt with in the first dairy course. Babcock testing, cattle judging, to give but two illustrations, are now taught in many high schools and taught well. With these subjects being covered in the secondary school, the college course must be revised, not necessarily eliminating such subjects, but modifying their presentation to avoid useless repetition.

2. *Conditions in the state.* Standardization of courses in all

states is not desirable. Each agricultural college shapes its work to train students for their own state conditions. It may be important in Wisconsin to emphasize cheese manufacture while it would be foolish to place such emphasis in Louisiana. The type of farming, and the position and condition of the dairy industry all are factors in determining what should be taught.

3. *Only one course to be given.* Too frequently the first course in dairying is designed as the logical foundation for a series of dairy courses to follow. Such an arrangement may be satisfactory if a separate course is given others, but is wrong if the course is the only one that students are required to take or are likely to take.

4. *Survey of dairying.* Assuming that the student is to get his first and only glimpse of the great dairy industry through this course, then it is essential that the course be filled with the kind of information that will correctly portray the industry, and the relation of each of the many branches. A great deal of time and effort can profitably be spent in the consideration of this one point.

5. *Time allotted.* Naturally a dairy instructor feels that the time allotted by the faculty for his course is far too short considering the importance of the subject. The time is set and good teaching demands that the maximum be crowded into the course so as to present a rounded whole. This will mean shortening here and there in order not to omit some vital part. Certain parts must not be presented in full at the expense of others, but the whole balanced to fit the time.

6. *Material of general interest.* To the specialist who has spent years of study of the subject, items of limited interest to the average person loom as important and sometimes are included in the first course. Such material should be used rarely.

7. *Divide material into general headings.* With the subject matter decided upon, then group it into related parts. For example: If dairy cattle judging is to be presented, then arrange the material that pertains to that subject together.

8. *Arrange material so that each part answers a specific problem.* In secondary school teaching this is called the problem method

and it seems well adapted to many undergraduate courses. At first it may seem the college students should be able to maintain interest over a considerable period keeping in mind the future goal. That they do not is, I believe, evident to anyone who has ever talked with agricultural students about chemistry during their first or second year. The application is too distant, too vague to interest them. The more specific the application, the greater the likelihood that it will be impressed upon the student's mind.

METHOD OF PRESENTATION

With the subject matter all selected, carefully arranged and and organized, there still remains the biggest problem of teaching; namely, the presentation to the class. A class, remember, that is composed of immature minds affected with a thousand distractions and compelled by our present system of class hours to attempt to absorb the reason for the reactions of certain chemicals one hour, the principles of English composition the following period, and be interested in and show enthusiasm for the life history of the algae the next period. Add to this, the fact that frequently the classes range from thirty to forty so that little individual attention may be given, and it is not surprising that all too frequently, the first course in dairying has become merely a series of lectures, with a text book assignment from time to time and a quiz to determine the class grade. As opposed to this method, our plan is to try to make the course so practical and interesting, that the student will appreciate the value and will study because he believes it is worth while. The preparation of the material to be given to the class and the actual presentation are so closely interwoven that they will be discussed together.

1. *Give proper emphasis.* Giving the proper emphasis to the essential facts saves the student time and creates a better spirit within the class. The average student greatly dislikes to have his time wasted by being compelled to remember a lot of unimportant facts.

2. *Make each period interesting.* It may seem puerile to some, that a college class presentation needs to be interesting but it is

exceedingly important. Frequently, the form of presentation that is most appealing to students may seem illogical to one with a greater knowledge yet if it will gain and keep attention it is worthy of use.

3. *Make the class work provoke thought and reasoning.* It has been said that if a college course stimulates thought, it is successful even if it conveys no information. There is sometimes a tendency for the instructor to appear in class and give a lecture which is merely a recitation of known facts all of which may be found better arranged in a book. Such a lecture may stimulate thought, but it is unlikely.

4. *Make the object clear.* The aim or underlying thought that each class period is to bring out or the part of the whole that is to be emphasized, should be stressed. Always keep the immediate object of the problem before the class and at the same time show its relation to the larger problem covered by the course.

5. *Each part should be a step toward the whole.* Each lesson should fit in toward the main goal and the information obtained should better fit the student to solve the next problem before him.

6. *Make the student work.* Each student is required to have the course outline. There the object or problem is outlined for each class period and for each laboratory period. In the outline for a class period the questions are asked that are to be answered or discussed at that period. References are given also where information may be found upon the subject. In the class period, the instructor brings out by class discussion the various opinions and ideas of the students, corrects misapprehension and shows the relationship of the problem to the whole subject. Under such a plan the student must work, since it is his reaction to the problem that is brought out and not a mere recitation of known facts.

With these principles in mind, at Nebraska we have tried to build a course in first year dairying that would be suitable for our State, for a three-hour course (two one-hour class periods and two two-hour laboratory periods), for men that probably had no dairy background, and may never have another dairy course.

OUTLINE OF CLASS PERIODS AND LABORATORIES

In arranging the class periods and laboratory exercises, it has been necessary to consider the relationship of one to the other as well as the logical development and the retention of interest. The arrangement given seems to give the most satisfaction under our conditions. Under our conditions, the laboratory period always follows the class period.

Class Period	*Laboratory Period*
Subject	*Subject*
1. Relation of dairying to agriculture; how it fits into agricultural practice. Future for the dairy industry.	1. Observation trip through college dairy barn and creamery. Attention is called to methods used in handling dairy cattle and dairy products. Mimeograph sheets of department's activities are given to each student to show the scope of dairying as existing at the college.
2. Relation of form to function in dairy cattle. What is a dairy cow? How different from other cows?	2. Use of score card in judging dairy cows. Application of the principles discussed in the class period.
3. Origin of cattle types. A background for studying breed characteristics.	3. Judging Ayrshire cows—comparative judging using only the essential parts of the cow.
4. Ayrshires—history, characteristics and present usefulness.	4. Judging Ayrshire—continuation of comparative judging.
5. Holstein-Friesians—history, characteristics and present usefulness.	5. Judging Holsteins—comparative. Same as first period with Ayrshires.
6. Guernseys—history, characteristics and present usefulness.	6. Judging Holsteins—comparative. Same as second with Ayrshires.
7. Jerseys—history, characteristics and present usefulness.	7. Judging Guernseys—comparative.
8. Brown Swiss, minor and dual purpose breeds, characteristics and present usefulness.	8. Judging Guernseys—comparative.
9. Methods of starting a dairy herd. The advantages and disadvantages of the different breeds having been discussed, the actual considerations necessary in selecting and buying dairy cows are brought out.	9. Judging Jersey's—comparative.

10. The herd sire, important characteristics, method of selection, care and feed.	10. Judging Jersey's—comparative.
11. Feeding—general principles.	11. Judging dairy bulls for type.
12. Feeding dairy cows in summer.	12. Selection of dairy cows and bulls as an investment.
13. Feeding dairy cows in winter.	13. Selection of dairy cattle as an investment. Continuation of 12.
14. Care of the cow, before, at and immediately after freshening.	14. Balancing rations to fit common roughages.
15. Feeding and care of the dairy calf.	15. Barn practice—dehorning calves, ringing bulls, clipping, trimming hoofs, etc.
16. Midsemester examinations.	16. Midsemester examinations.
17. Sampling of milk, plain and composite; the use of preservatives. Explanation of the operation of the Babcock test for milk.	17. Testing whole milk by the Babcock test.
18. Principles of the Babcock test; causes and remedies; defective tests.	18. Testing whole milk by the Babcock test.
19. Babcock test for cream, skim-milk, buttermilk and whey.	19. Testing cream by the Babcock test.
20. Milk secretion.	20. Testing cream by the Babcock test.
21. Milk composition.	21. Keeping cow testing association records.
22. Standardization of dairy products.	22. Practice in standardization.
23. Cream separation.	23. Testing skim-milk, buttermilk and whey.
24. Choosing and operating a separator.	24. Study of the mechanical construction of a separator.
25. Bacteria and their relation to milk.	25. Operation of cream separators.
26. Care of milk and cream on the farm, milking machines.	26. Cooling and care of milk.
27. Principles of buttermaking.	27. Demonstration of churning butter commercially in the creamery.
28. Principles of cheese making.	28. Demonstration of making cheese in the creamery.
29. Principles of ice cream making.	29. Demonstration of ice cream making in the creamery.
30. Food value of dairy products.	30. Judging butter, cheese and milk.
31. Methods of selling milk.	31. Calculation of returns from different methods of selling milk.
32. Visit to a dairy farm, milk plant and dairy manufacturing plant.	32. Visit to dairy plants.
33. Final examination.	33. Final examination.

The lectures and laboratories are not arranged in the exact order that is desired, but they are arranged so that as far as possible, the laboratory will follow the lecture period where the subject is discussed. There may be some difference of opinion as to the desirability of including some subjects under a first year course. From our standpoint and under our conditions this arrangement is believed to be most satisfactory.

CLASS PERIODS METHODS AND MATERIAL

In the first class period usually there has been no chance for preparation so that with the outlines before the class the instructor proceeds to answer the questions bringing out discussion wherever possible.

LESSON 1

Relation of Dairying to Agriculture

Object. To present a brief survey of the dairy industry and to indicate the value of dairy training.

1. What is dairying?
2. Why is the subject of dairying included in an agricultural course?
3. What are the usual steps or stages in agricultural development? Explain the reason for this sequence of development.
4. What are the advantages and disadvantages of dairying as a business?
5. What are the different types of dairy farms? What are the local conditions that make for the success of each type?
6. What will be the use of dairy training to you as an average student?
7. In order to show the extent of the dairy industry in the United States and Nebraska tabulate for the next period the following:
   a. Number of dairy cattle in U. S., Nebraska and home county? How many dairy cows per square mile in each?
   b. Pure bred dairy cattle in U. S. and in Nebraska?
   c. Value of dairy cattle in U. S., in Nebraska and home county? Compare with total live stock values in each.
   d. Value of dairy products produced in U. S., in Nebraska, and home county? Compare with other agricultural products.
   e. Total milk production in U. S., in Nebraska, and home county?
   f. Uses of milk in U. S. by percentages?
   g. Compare per capita consumption of milk, butter and cheese in the U. S., Switzerland, Denmark and Germany?

At the first class period, a questionnaire is given each student asking the following information. This is an endeavor to get the

background of the student in order to present the course most effectively.

GENERAL INFORMATION FROM STUDENTS

Give the following information in regard to your own experiences:

1. Do you live on a farm? If the answer is "Yes" answer all questions; if "no" answer only those questions that are starred *.
2. Do you milk cows on your home farm? How many?
3. Is dairying a minor or major part of the business on your farm?
4. What breed of cows are used on your farm?
5. Are the cows grades or pure breds?
6. What breed of cows prevail in your community?
7. Is a pure bred bull used on your farm?
8. Do you know the yearly production of each of your cows?
9. What means of keeping milk records is used?
10. What is the average production per cow per year in your herd?
11. Do you have a milking machine? What kind? Is it satisfactory?
12. In what form do you sell your milk? Why?
13. Do you have a cream separator? What kind? Why?
14. What part of the total feed for your cows do you raise on the farm?
15.* Do you consider dairying a profitable business?
16. What are the main crops on your home farm?
17.* What do you expect to do when through college? Why?
18.* What are some of the main points that you would like to get from this first course in dairying?
19.* Do you expect to take other dairy courses?
20.* What has been the extent of your dairy training before coming to college?
21.* How many dairy plants of any kind are there in your town? What do they manufacture?
22.* Have you ever visited a large dairy plant and observed the handling of dairy products on a large scale?

From this information it is hoped to tie the students' local interest to the work presented in the course. The questionnaire used is designed to be used with a class that contains a large majority of farm-raised boys.

It should be mentioned, that at the first class period use of the outline and the reference books is explained. The next lesson or problem is outlined also and any needed explanation made.

LESSON 2

Relation of Form to Function in Dairy Cattle

Object. To determine the importance of judging in the selection of dairy cows.

1. How would you select a dairy cow for your own herd?

2. What is meant by dairy type? Compare dairy with breed type and explain differences?
3. What is a score card? What is it's purpose?
4. What points are most emphasized on the score card and why?
5. How does a breed score card differ from general dairy cattle score cards? Why?
6. What is meant by the following terms: breed, pure bred, scrub, grade, pedigree, family?
7. What are the purposes of breed associations?

The student should appear at the second class period prepared to answer these questions all of which are discussed in the list of references given in the outline. The instructor then must bring out by class discussion the reaction of the student to the problem of the relation of form to function. The instructor should also correct any false impression that may have developed.

LESSON 3

Origin of Dairy Cattle Types

Object. To bring out by the study of the origin of cattle, the present day types and the breed characteristics.

1. For what purposes have cattle been developed?
2. What are the milk producing animals of the world? Why are different animals used in different countries?
3. Compare present day dairy cow with the early cows?
4. What has brought about the change in dairy cows?
5. What are ruminants? For what purposes are they best fitted? Name several common ruminants?
6. What are the chief characteristics of the division of the genus Bos; Bos Indicus; Bos primigenius and Bos Longifroms? What breeds today show these characteristics?
7. Describe and explain two ways in which types of cattle may develop?

From that lesson a ground work is laid upon which the breeds of dairy cattle may be discussed.

LESSON 4

Dairy Breeds—Ayrshire

Object. To bring out by a discussion of history and characteristics the usefulness of each particular breed.

1. (a) Name the major breeds of dairy cattle?
   (b) Name the minor and dual purpose breeds?
2. Why have some breeds developed to a great extent than others? Explain answer.

3. Considering the original environment, the character of the people, etc., is the Ayrshire cow the type that you would expect? Why?
4. What in detail are the characteristics of the Ayrshire?
5. For what environmental and market conditions would you select Ayrshires? Explain.
6. Where are the largest numbers of Ayrshires in the United States? Why?
7. What are the number of pure bred and grade Ayrshires in United States and in Nebraska? How does the breed compare in importance in United States and Nebraska?
8. What is the average production of Ayrshire advanced registry cows in milk and fat? What is the average per cent of fat?
9. What particular characteristics has Ayrshire milk? For what purpose is it especially useful?
10. Name five of the leading milk producing cows of the Ayrshire breeds and give production?
11. Name and locate the organization that registers Ayrshire cattle in the United States?

In this lesson an effort is made to consider cattle that are used for dairy purposes and then to bring out in some detail one breed, the Ayrshire. In the class discussion led by the instructor local relationships can be established.

If it were to be summarized in outline form, our conception of the first course in dairy husbandry would be somewhat as follows:

I. Planning the course.
   1. According to training of the student.
   2. With reference to conditions in the state.
   3. As the only course that students will take.
   4. To present a survey of the dairy industry.
   5. To meet the allotted time.
   6. To cover material of general interest.
   7. Arrangement of subject matter under general headings.
   8. Each part to answer a specific question.

II. Presentation of the course.
   1. Proper emphasis.
   2. Interesting.
   3. Provocative of thought and reasoning.
   4. Object clearly set out.
   5. Each part a step toward the whole.
   6. Make the students work.

BACTERIAL ACTION IN THE COAGULATION OF EVAPORATED MILK*

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The coagulation of unsweetened condensed (evaporated) milk has occasioned considerable loss to the condensed milk undustry. Instances have been recorded of the spoilage of large numbers of cans, sometimes involving practically entire batches and, again, occurring frequently enough among the cans of single batches to render exceedingly doubtful the delivery of the milk into the hands of the consumer in a perfect, sweet, sterile condition. Chemical composition has been important in limiting the extent of sterilizing and excessive percentages of solids have in some cases been responsible for coagulation upon sterilizing. In others the high percentage of solids has induced incomplete sterilization because of the effort to prevent curdling during the exposure to heat.

Curdling due to bacterial action after sterilization has been recognized and Hammer (1) has isolated and described an organism which he encountered as a cause of coagulation and spoilage involving considerable loss to the condensery experiencing the trouble. He named this organism *Bacillus coagulans*.

PRESENT INSTANCE OF TROUBLE

The work herein reported was done in studying an outbreak of trouble in a condensery due to the coagulation of evaporated milk after sterilization and development of so-called "flat-sours." It had occasioned considerable anxiety on account of the sporadic nature of the epidemic and the failure of a number of changes in methods of manufacture to stop the trouble. From the information given it was impossible to judge whether the difficulty was a chemical one, involving a limitation in the percentage of total solids permitting sterilization by heat, or a bacteriological dis-

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turbance caused by the action of bacteria surviving the heat exposure during sterilization.

EXAMINATION OF MILK SUBMITTED

Several cans of the curdled evaporated milk were submitted. After removal of samples for bacteriological study an examination was made of the contents. The milk was found to be definitely curdled with irregular masses and lumps of curd present, and to possess a slightly bitter flavor of a cheesy nature but not unpleasant. No free whey was apparent and no gas-escape was noted upon opening. None of the cans submitted was bulged.

While at the outset there was no information available indicating whether the defect was of bacteriological nature or a result of an unfortunate high solids composition, the physical examination of the curdled milk indicated biological activity. This was confirmed by the plating of the milk for determination of viable bacteria. One can gave a count of 9,000,000 colonies per cubic centimeter and another showed but 75,000. Several weeks elapsed between platings and it is likely that considerable numbers died out in the interval. Direct transfers were made at time of plating from the milk in the cans to tubes of litmus milk, which were incubated to allow enrichment of any organisms present. Such tubes curdled after a number of days, depending on the temperature used, and were also plated for study of the organisms present and isolation in pure culture.

The same organism was obtained from all sources examined —plating of original cans and of enrichment tubes—and the milk in the cans appeared to be essentially a pure culture. The organism isolated was found, upon study morphologically, culturally, and biochemically, to correspond with the *Bacillus coagulans* of Hammer.

STUDY OF ORGANISM ISOLATED

Observations recorded here constitute merely a brief survey of a few of the important characters of the organism isolated, serving to mark its identity as *B. coagulans*.

Morphologically, the causative organism was rod-shaped, gen-

erally occurring singly, Gram-positive in young cultures, but predominantly negative in old. The predominating size in young agar cultures was 3.5 to 5.0 microns long and 0.5 micron wide. Occasional cells had the appearance of containing spores but these were not at all distinct. The water of condensation in twenty-four-hour whey agar slope cultures showed the rods to be actively motile.

The growth on a whey agar slant was fair in amount after twenty-four hours at 37°C., echinulate, glistening, whitish, slightly raised, and increasing in amount with age, with heavy turbidity in the water of condensation. Development was much slower at room temperature.

The colony on whey agar was 1 to 2 mm. in diameter after four days at 37°C., circular with entire edge, slightly raised, glistening, and whitish; clouded areas occurred surrounding the colonies, due to the penetration of acid into the medium. At room temperature colonies were pin-point in size after one week.

In litmus milk a slight reduction was evident in the bottom of the tube after twenty-four hours at 37°C. Complete coagulation occurred usually after three days with young, vigorous cultures; a red band formed at the surface, and there was a slight contraction of the curd in some cases; no gas was formed. At room temperature about five days was required for the first change to appear, and ordinarily coagulation occurred in about thirty days.

The acidity production was studied in flasks of sterilized skim milk inoculated with the organism and held at different temperatures. Beginning coagulation was noted at acidities as low as 0.38 per cent and 0.39 per cent, thus confirming the results secured by Hammer in the original isolation of *B. coagulans* and indicating the activity of a rennin-like principle in the production of initial coagulation. Total acid production at 37°C. after fifteen days ranged around 0.85 to 0.90 per cent.

REPRODUCTION OF DEFECT BY ARTIFICIAL INOCULATION

In order to demonstrate conclusively the relationship of the organism isolated to the abnormal, curdled condition of the original milk submitted, inoculation experiments were carried out

on cans of normal evaporated milk. The usual method of introducing suspensions of the organism through a hole punched in the tin with a sterile nail was followed. Control cans were opened and in some cases sterile water added before soldering over. The cans were incubated at both 37°C. and room temperature. They commonly exhibited a slight bulging after several days at 37°C. The curdled, lumpy condition of the original spoiled milk was reproduced, accompanied by the slightly bitter, cheesy flavor of the cans submitted. The odor was characteristically sweetish, slightly cheesy. This condition was obtained in cans held ten days at 37°C. Inoculated cans allowed to stand without agitation were found to have the contents in a solid cake, more or less firm according to the temperature and time of incubation. Acidity production was around 0.9 to 1.0 per cent. The inoculated cans were examined bacteriologically and found to be pure cultures of *B. coagulans*, the organism inoculated.

THERMAL DEATH POINT OF ORGANISM

Having demonstrated that the coagulation in the original cans was due to bacterial action, it became necessary to determine how resistant the organism was to heat. The cans submitted had been sterilized in a batch exposed to 238°F. for twenty minutes and were typical of a number of cases of so-called "flat-sour" that developed some time after sterilization.

Preliminary tests with various cultures showed that the organism survived the ordinary test for spores, 80°C for ten minutes. Milk was the medium used and fresh transfers were used for heating, the milk itself being kept at a temperature of 80°C. for ten minutes.

Further trials with fresh milk transfers of several cultures were made by heating the tubes of litmus milk in a bath of boiling water. The data in table 1 are typical of the temperature changes found, the tubes of cultures and the water bath both being at 85°F. to start, and an extra tube of milk being placed with the culture tubes for the thermometer.

Tubes were cooled down quickly in cold water after taking out of the bath. These results showed that the organism could

withstand three minutes exposure to temperatures practically that of boiling water, where the temperature of the culture itself reached 210°F. The milk cultures showed the usual changes—reduction of the litmus and coagulation—after several days incubation at 37°C.

Further trials for thermal death point were made with the autoclave, using steam under pressure, fresh milk cultures in cotton-stoppered test tubes being used as before. These were placed in a container together with a tube of milk in which a maximum registering thermometer was placed. The container was placed in the center of the autoclave and a second registering

TABLE 1

TIME	TEMPERATURE		TUBE NUMBER	GROWTH ON INCUBATION
3:10 p.m. (start)	Bath	Tube		
	°F.	°F.		
3:11	100			
3:11½		100		
3:13	140	126		
3:14½	170			
3:15	180	164		
3:16		176		
3:17	208	192	1	+
3:18	Boiling	207	2	+
3:19		210	3	+
3:20		210	4	+

thermometer placed on a stand beside it, the autoclave being otherwise empty. In this way temperatures were obtained of both the autoclave and the cultures themselves. Cultures from different isolations were used; after autoclaving, the pressure was let down as rapidly as possible and the tubes cooled in water; incubation was at 37°C.

Under these conditions cultures survived where the milk medium actually reached 223°F., the temperature being 223° for two minutes, between 212° and 223° for five minutes, and between 193° and 223° for twelve minutes. The temperature of the autoclave to which the milk was exposed was 233° to 234°

for thirteen minutes (fifteen minutes at about 7.5 pounds pressure). In other trials cultures reached 225° and survived, the time of exposure to the maximum temperature in the autoclave being twelve minutes, and the milk tubes being 212° to 225° for four minutes.

Cultures exposed to a temperature in the autoclave of 233° to 235° for fifteen minutes (seventeen minutes at 7.5 to 8.0 pounds pressure) were killed, the milk itself reaching 234° and being between 212° and 234° for six minutes, and between 225° and 234° for four minutes.

REFERENCE

(1) HAMMER, B. W.: Bacteriological studies on the coagulation of evaporated milk. Iowa Agr. Exp. Sta. Res. Bull. 19, 1915.

VARIABILITY IN COMPOSITION OF BUTTER FROM THE SAME CHURNING IN RELATION TO WORKING*

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Uniformity in the distribution of the water, salt, curd, and milk fat in creamery butter is highly desirable but seldom attained to the satisfaction of exacting creamerymen. This lack of uniformity is evidenced by the variation in the composition of butter prints from the same churning. It is noticeable in the product of the best managed creameries, where careful attention is given to composition control, and often results in unintentional violation of governmental regulations pertaining to the composition of butter. This station found that over 30 per cent of the prints sold at retail markets contain less than 80 per cent milk fat, while over 20 per cent of the prints contain 16 per cent or more water. Most creamerymen believe that such violations may be largely attributed to the nonhomogeneous character of butter.

According to Lee, Hepburn, and Barnhart (1) there is a variation in water content, ranging from 0.1 to 1 per cent, between different samples representing butter from the same churning. Hunziker, Mills, and Spitzer (2) found the following averages for water content in butter from different parts of the churn: gear end, 15.91 per cent; middle, 15.44 per cent; and gate end, 16.33 per cent. Guthrie and Ross (3) found 17.6 per cent of 51 packages with a difference of 1 per cent or more water in adjacent samples, 54.9 per cent with a difference of 0.5 per cent; while in 34.2 per cent of the packages, there was a difference of 0.2 per cent salt in adjacent samples.

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The results of these investigations show a large variation in the distribution of water and salt in butter. It is generally understood that insufficient working of butter may cause excessive variation in composition, and some butter experts advocate that the working process be prolonged until the texture of the butter is very close and the body quite dry. Such working, it is said, will result in less variation in the composition of butter coming from the same churning.

The investigation reported in this paper was conducted for the purpose of determining the effect of prolonged working of butter upon the distribution of the water, salt, curd, and fat content.

MATERIALS AND METHODS

Butter used in the investigation was manufactured at the Purdue Creamery in a single roll Cherry Dreadnaught Churn, No. 23 with a capacity (half full) of 3033 pounds of cream. The size of the churnings were varied from 876 to 2257 pounds of cream. All churnings were made during the months of December, 1926, January and February, 1927.

The samples consisted of 300 grams of butter taken from the churn with a trier and transferred to pint size, glass stoppered jars. The preparation of the samples, and the water and fat analyses were done in accordance with the methods of analysis of the Association of Official Agricultural Chemists (second edition, paragraphs 67, 68 and 69). The salt and curd contents were determined as follows. The salt was washed from the fat free solids, remaining in the crucible after the extraction of the fat, and titrated with silver nitrate. The difference between the fat free solids and the salt content was taken as the curd content.

EXPERIMENTAL

Ten churnings were made from which samples of butter were obtained for analysis. Nine samples were taken from each of the ten churnings at the following stages of the working process: three samples when the butter had been worked thirty revolutions, three when worked forty-five revolutions, and three when

worked sixty revolutions. Of each set of three samples thus taken, one sample was taken at the gate end of the churn, one from the middle, and a third at the gear end of the churn. The samples were obtained by inserting an eighteen-inch butter trier the full depth of the butter roll in the churn and transferring the entire plug to the sample jar. The operation was repeated until the full sample was obtained, care being taken to avoid surface water pockets and drippings from the wall of the churn.

The cream used in the churnings consisted of the regular run of farm skimmed cream received at the Purdue Creamery. It was standardized to 0.25 per cent acid with magnesia lime and then flash pasteurized at a temperature of 185°F., cooled over a

TABLE 1

Churning data pertaining to the cream used in the ten churnings of the experiment

CHURNING NUMBER	AMOUNT OF CREAM	FAT CONTENT	RIPENING PERIOD	RIPENING TEMPERATURE	CHURNING TEMPERATURE
	pounds	*per cent*	*hours*	*°F.*	*°F.*
1	876	30.5	3	50	50
2	1,046	32.0	4	52	53
3	1,175	34.0	3	48	48
4	1,352	33.5	1	52	52
5	1,288	35.5	3	50	50
6	1,483	33.0	2	52	53
7	1,661	32.0	3	52	52
8	1,699	35.0	1	50	50
9	1,969	35.0	1	53	53
10	2,257	33.5	1	50	50

tubular surface cooler to near the churning temperature and ripened in a vat ripener, there being about 10 per cent starter added. The pounds of cream, its milk fat content, ripening period and temperature, and the churning temperature for each churning are shown in table 1.

The cream was churned until the butter granules became a trifle larger than grains of wheat. The temperature of the wash water was 4°F. less than that of the buttermilk. The water was drained from the churn through the gate, and then the butter was worked five revolutions. The doors were then opened a

TABLE 2

Variation in the water content of butter from different parts of the churn as affected by working

NUMBER OF REVOLUTIONS WORKED	CHURNING NUMBER	PERCENTAGE OF WATER					
		Gate end	Middle	Gear end	Average of the three	Average deviation	Coefficient of variability
30	1	14.73	14.85	14.52	14.70	0.120	0.82
	2	13.62	13.43	13.29	13.45	0.118	0.88
	3	14.11	14.08	13.93	14.04	0.073	0.52
	4	13.62	13.99	13.60	13.74	0.171	1.24
	5	13.94	13.88	13.99	13.94	0.038	0.27
	6	14.11	14.34	14.20	14.22	0.084	0.59
	7	14.73	15.03	14.78	14.85	0.124	0.83
	8	15.55	15.67	15.33	15.52	0.128	0.82
	9	14.52	14.77	14.45	14.58	0.127	0.87
	10	14.10	14.13	13.96	14.06	0.069	0.49
Average		14.30	14.42	14.20	14.30	0.105	0.73
45	1	15.11	14.82	14.94	14.96	0.104	0.70
	2	14.07	13.90	13.88	13.95	0.080	0.57
	3	14.92	14.66	14.41	14.66	0.169	1.15
	4	14.17	14.09	14.19	14.15	0.040	0.28
	5	14.97	15.00	14.98	14.98	0.009	0.06
	6	15.00	15.55	15.35	15.30	0.200	1.31
	7	15.60	15.61	15.50	15.57	0.047	0.30
	8	16.72	17.05	16.62	16.79	0.171	1.01
	9	15.19	14.91	14.70	14.93	0.169	1.13
	10	14.07	14.03	13.75	13.95	0.133	0.95
Average		14.98	14.96	14.83	14.93	0.112	0.75
60	1	14.81	14.88	15.08	14.92	0.102	0.68
	2	14.26	14.11	13.86	14.08	0.144	1.02
	3	15.48	14.98	15.13	15.20	0.191	1.26
	4	15.00	15.06	14.94	15.00	0.040	0.27
	5	15.96	15.97	15.98	15.97	0.007	0.04
	6	15.93	16.45	16.20	16.19	0.176	1.09
	7	16.03	16.55	16.46	16.35	0.211	1.29
	8	16.92	17.26	16.94	17.04	0.147	0.86
	9	15.15	15.02	14.75	14.97	0.149	0.99
	10	14.29	14.21	13.99	14.16	0.116	0.82
Average		15.38	15.45	15.34	15.39	0.128	0.83

trifle and the churn rotated so as to permit the remnants of wash water to drain through them. The butter was salted by the trench method at the rate of 4 pounds of salt to 100 pounds of fat, after which, the churn was closed tight and the working continued without further attempt to regulate the composition of the butter.

Results

The effect of prolonged working upon the distribution of the water, salt, curd, and fat in butter is shown by tables 2, 3, 4, and 5, respectively. These tables, in addition to the original data, show the average deviations and the coefficients of variability of the three samples taken from each churning at the different stages of the working process, namely; thirty, forty-five, and sixty revolutions.

In table 2 it well be noted that the averages of the coefficients of variability indicate that the distribution of water become more variable as the working process was prolonged. However, this is not true of individual churnings. Churning 1, 4, and 5 show the opposite effect, while 2 and 7 show a less variable distribution of water at forty-five revolutions than at thirty, but a more variable distribution at sixty revolutions. Churning number 3 alone shows an increase in variability throughout the working process; while in churnings 6, 8, 9, and 10 the variability decreased from forty-five to sixty revolutions, yet it remained greater at sixty than at thirty. In these churnings, size of the churning undoubtedly exerted some influence upon the distribution of water. The size of the churnings increased in the order of their numbers, from number 1, the smallest, to number 10, the largest, as may be recalled from table 1. Table 2 shows that in all of the five larger churnings, numbers 6 to 10 inclusive, the variability is greater at sixty revolutions than at thirty, likewise, in four churnings, greater at forty-five revolutions than at thirty; while but two churnings of the five smaller ones show greater variability at sixty revolutions than at thirty, and only one churning shows a greater variability at forty-five revolutions than at

TABLE 3

Variation in the salt content of butter from different parts of the churn as affected by working

NUMBER OF REVOLUTIONS WORKED	CHURNING NUMBER	PERCENTAGE OF SALT					
		Gate end	Middle	Gear end	Average of the three	Average deviation	Coefficient of variability
30	1	2.73	2.74	2.23	2.57	0.224	8.73
	2	3.27	3.49	4.00	3.59	0.278	7.75
	3	2.78	2.65	2.54	2.66	0.084	3.16
	4	2.32	2.27	1.80	2.13	0.220	10.33
	5	2.60	2.60	2.40	2.53	0.089	3.51
	6	2.78	2.40	1.77	2.32	0.364	15.71
	7	2.29	2.41	2.25	2.32	0.064	2.76
	8	2.18	2.34	2.58	2.37	0.144	6.08
	9	3.40	3.56	2.84	3.27	0.284	8.69
	10	3.19	3.66	3.73	3.53	0.224	6.35
Average.....		2.75	2.81	2.61	2.73	0.198	7.31
45	1	2.87	2.58	2.39	2.61	0.169	6.47
	2	3.53	3.84	4.09	3.82	0.193	5.05
	3	2.99	2.75	2.62	2.79	0.102	3.66
	4	2.49	2.34	2.14	2.32	0.122	5.25
	5	2.69	2.81	2.88	2.79	0.069	2.47
	6	3.00	2.79	2.23	2.67	0.296	11.07
	7	2.60	2.69	2.50	2.60	0.064	2.46
	8	2.39	2.77	2.87	2.68	0.191	7.13
	9	3.63	3.61	3.00	3.41	0.276	8.09
	10	3.24	3.50	3.66	3.47	0.151	4.36
Average.....		2.94	2.97	2.84	2.92	0.167	5.73
60	1	2.84	2.74	2.56	2.71	0.102	3.76
	2	3.64	3.78	4.02	3.81	0.136	3.57
	3	3.09	2.90	2.93	2.97	0.076	2.56
	4	2.74	2.62	2.40	2.59	0.124	4.79
	5	3.07	3.08	3.15	3.10	0.033	1.06
	6	3.18	3.16	2.57	2.97	0.267	8.99
	7	2.75	2.91	2.84	2.83	0.056	1.98
	8	2.57	2.81	3.01	2.80	0.151	5.41
	9	3.63	3.64	3.06	3.44	0.256	7.43
	10	3.21	3.56	3.73	3.50	0.193	5.51
Average.....		3.07	3.12	3.03	3.07	0.139	4.51

TABLE 4

Variation in the curd content of butter from different parts of the churn as affected by working

NUMBER OF REVOLUTIONS WORKED	CHURNING NUMBER	PERCENTAGE OF CURD					
		Gate end	Middle	Gear end	Average of the three	Average deviation	Coefficient of variability
30	1	0.69	0.61	0.61	0.64	0.038	5.96
	2	0.65	0.74	0.72	0.70	0.036	5.12
	3	0.76	1.03	1.26	1.02	0.171	16.81
	4	0.79	0.79	0.86	0.81	0.029	3.56
	5	0.52	0.55	0.62	0.56	0.031	6.39
	6	0.83	0.72	0.73	0.76	0.047	6.18
	7	0.81	0.85	0.89	0.85	0.027	3.18
	8	0.52	0.56	0.63	0.57	0.040	7.02
	9	0.70	0.62	0.61	0.64	0.036	5.60
	10	0.58	0.57	0.43	0.53	0.064	12.14
Average.....		0.68	0.70	0.74	0.71	0.052	7.20
45	1	0.60	0.74	0.74	0.69	0.062	8.94
	2	0.59	0.57	0.66	0.61	0.038	6.26
	3	0.96	0.75	1.16	0.96	0.138	14.42
	4	0.60	0.64	0.64	0.63	0.018	2.87
	5	0.53	0.48	0.54	0.52	0.024	4.64
	6	0.77	0.86	0.81	0.81	0.029	3.57
	7	0.66	0.57	0.77	0.67	0.071	10.64
	8	0.61	0.73	0.69	0.68	0.044	6.49
	9	0.69	0.69	0.71	0.70	0.011	1.58
	10	0.55	0.52	0.61	0.56	0.033	5.89
Average.....		0.66	0.66	0.73	0.68	0.047	6.53
60	1	0.70	0.73	0.77	0.73	0.022	3.00
	2	0.63	0.57	0.72	0.64	0.053	8.28
	3	0.89	1.00	1.01	0.97	0.051	5.27
	4	0.57	0.87	0.80	0.75	0.118	15.79
	5	0.73	0.75	0.75	0.74	0.009	1.21
	6	0.83	0.77	0.78	0.79	0.022	2.77
	7	0.81	0.82	0.82	0.82	0.003	0.37
	8	0.78	0.71	0.69	0.73	0.038	5.23
	9	0.54	0.62	0.65	0.60	0.042	6.96
	10	0.54	0.51	0.60	0.55	0.033	6.00
Average.....		0.70	0.74	0.76	0.73	0.039	5.49

TABLE 5

Variation in the fat content of butter taken from different parts of the churn as affected by working

NUMBER OF REVOLUTIONS WORKED	CHURNING NUMBER	PERCENTAGE OF FAT					
		Gate end	Middle	Gear end	Average of the three	Average deviation	Coefficient of variability
30	1	81.85	81.80	82.64	82.10	0.364	0.44
	2	82.46	82.34	81.99	82.26	0.182	0.22
	3	82.35	82.24	82.27	82.29	0.044	0.05
	4	83.27	82.95	83.74	83.32	0.280	0.34
	5	82.94	82.97	82.99	82.97	0.018	0.02
	6	82.28	82.54	83.30	82.71	0.398	0.48
	7	82.17	81.71	82.08	81.99	0.184	0.22
	8	81.75	81.43	81.46	81.55	0.138	0.17
	9	81.38	81.05	82.10	81.51	0.393	0.48
	10	82.13	81.64	81.88	81.88	0.162	0.20
Average.....		82.26	82.07	82.44	82.26	0.216	0.26
45	1	81.42	81.86	81.93	81.74	0.178	0.22
	2	81.81	81.69	81.37	81.62	0.169	0.21
	3	81.13	81.84	81.81	81.59	0.309	0.38
	4	82.74	82.93	83.03	82.90	0.107	0.13
	5	81.81	81.71	81.60	81.71	0.071	0.09
	6	81.23	81.80	81.61	81.55	0.211	0.26
	7	81.14	81.13	81.23	81.17	0.044	0.05
	8	80.28	79.45	79.82	79.85	0.287	0.36
	9	80.49	80.79	81.59	80.96	0.424	0.52
	10	82.14	81.95	81.98	82.02	0.076	0.09
Average.....		81.42	81.51	81.60	81.51	0.187	0.23
60	1	81.65	81.65	81.59	81.63	0.027	0.03
	2	81.47	81.54	81.40	81.47	0.047	0.06
	3	80.54	81.12	80.92	80.86	0.216	0.27
	4	81.69	81.45	81.86	81.67	0.144	0.18
	5	80.24	80.20	80.12	80.19	0.044	0.05
	6	80.06	79.62	80.45	80.04	0.282	0.35
	7	80.41	79.72	79.88	80.00	0.269	0.34
	8	79.73	79.22	79.36	79.44	0.198	0.25
	9	80.68	80.72	81.54	80.98	0.373	0.46
	10	81.96	81.72	81.68	81.79	0.117	0.14
Average.....		80.84	80.70	80.88	80.81	0.172	0.21

thirty. Of the ten churnings, seven show a greater variability in water content at sixty revolutions than at thirty.

Table 3 shows that the distribution of salt in butter became less variable as the working process was prolonged. Churnings 1, 2, 4, 5, 6, 7, and 9 show a continuous decrease in variability throughout the working process. Churning 3 and 8 show greater variability at forty-five revolutions than at thirty, but less variability at sixty, while churning 10 shows less variability at forty-five and sixty revolutions than at thirty, but greater variability

TABLE 6

	30 REVOLUTIONS	45 REVOLUTIONS	60 REVOLUTIONS
Water	0.105	0.112	0.128
Salt	0.198	0.167	0.139
Curd	0.052	0.047	0.039
Fat	0.216	0.187	0.172

TABLE 7

	CHANGES IN MEANS OF AVERAGE DEVIATIONS FROM	
	30 to 45 revolutions	30 to 60 revolutions
Water	+0.007	+0.023
Salt	−0.031	−0.059
Curd	−0.005	−0.013
Algebraic sums	−0.029	−0.049
Fat	−0.029	−0.044

at sixty revolutions than at forty-five. Thus all ten churnings show a more even distribution of salt at 60 revolutions than at thirty,while eight of the ten churnings show a more even distribution at forty-five revolutions than at thirty.

Variation in the curd content of butter from different parts of the churn as affected by working is shown in table 4. Here it is noted that seven of the ten churnings show more even distribution of curd in the butter worked forty-five and sixty revolutions than in the butter worked thirty. Churnings 2, 4, and 9 show greater

variability at sixty than at thirty revolutions, while churnings 1, 7, and 2 show greater variability at forty-five revolutions than at thirty. The averages of the coefficients of variability, also of the average deviations, show less variability as the working process is prolonged.

Table 5 shows the variation in the fat content of butter taken from different parts of the churn as affected by working. It will be noted that the mean of the average deviations decreased 0.029 per cent from thirty to forty-five revolutions, and 0.015 per cent from forty-five to sixty revolutions. Small decreases are likewise noted in the respective coefficients of variability.

DISCUSSION

The variation in the composition of salted butter, from a commercial standpoint, is determined by the distribution of the three chief non-fatty constituents, namely; water, salt, and curd. Uneveness of curd, water and salt, or brine distribution results in variability in the fat content and lack of uniformity in the composition of the butter as a whole. This relation is shown by the comparison, of the algebraic sums of the changes in the means of the average deviations of the non-fatty constituents during the different stages of the working process, with the corresponding changes in the fat content. The means of the average deviations of the four constituents at the three stages of the working process as shown in tables 2, 3, 4, and 5, are given in table 6.

The changes in the means, of the four constituents from thirty to forty-five and sixty revolutions, with the algebraic sums of the changes of the non-fatty constituents are shown in table 7.

These figures show that the algebraic sums of the changes in the average deviations of the non-fatty constituents are approximately equal to the corresponding changes in the average deviations of the fat. Variability in the fat content of butter, therefore, expresses the variability in the composition of butter as a whole.

The composition of the butters reported in this paper, as expressed by the variability on the fat content, became less variable

as the working process was prolonged. The mean of the average deviations decreased from 0.216 per cent at thirty revolutions, to 0.187 at forty-five, and 0.172 at sixty. This reduction effected by thorough working is of commercial significance, in that, it demonstrates that insufficient working is one of the several factors that may cause a variation in the composition of butter coming from the same churning.

Of the three non-fatty constituents considered in this investigation, the curd was the most variable, the salt next, and the water least. On the other hand, the curd content had the least effect upon the variability in the composition of the butter as a whole, since it is present in such small amounts as compared with the water and salt. The salt content exerted the greatest influence upon the variability in the composition of the butter, and the water content the next greatest, as shown by their average deviations.

The variation in the water content is not as large as the variation shown in the results of some former investigations. Hunziker, Mills, and Spitzer (2) found as much as 2.94 per cent variation in water content of butter from different parts of the churn, and a variation of 1 per cent or more in the water content in ten out of eighteen churnings. The greatest variation found by the investigation reported in this paper was 0.55 per cent, while but two out of the ten churnings worked forty-five revolutions, and two out of ten churnings worked sixty revolutions, and none of the ten churnings worked thirty revolutions, showed variations greater than 0.5 per cent between different samples taken from the same churning.

The average of the coefficients of variability in the water content of the five smaller churnings, which ranged in size from 676 to 1288 pounds of cream, decreased from 0.75 per cent at thirty revolutions to 0.65 at sixty. The opposite results were shown by the five larger churnings which ranged in size from 1483 to 2257 pounds of cream. In these churnings, the variability increased from 0.72 per cent at thirty revolutions to 1.01 per cent at sixty. In four of these churnings, numbers 6, 8, 9, and 10, the variability

increased from thirty to forty-five revolutions and then decreased from forty-five to sixty revolutions, yet it remained greater at sixty than at thirty revolutions.

The decrease in variability in water content of the small churnings from thirty to sixty revolutions; and the increased variability of the larger churnings from thirty to forty-five revolutions, followed by a decrease at sixty revolutions, may be explained by the combined influences of salt and working upon the size of the water droplets present in the butter.

It is generally understood that, during the early stages of the working process of salted butter, there is a marked decrease in the number of small droplets and a decided increase in the number of the larger droplets. The working process may be continued, however, until there is a redivision of the water droplets resulting in the reduction of size to nearly the point that prevailed before the salting and working commenced.

The increase in size of the water droplets during the early stages of the working process results in a less even distribution and greater variability in water than at the stage before the salting and working was commenced. Prolongation of the working process from the early stages eventually reduces the size of the droplets and results in a more even distribution of the water and less variability. Thus in all churnings the variability of the water content increases to a certain point and then begins to decrease, approaching the original state of distribution before the salt was added and the working commenced. In the small churnings of this investigation the turning point was reached before the first observed stage of the working process namely, thirty revolutions. The comparison of the observations at thirty, forty-five, and sixty revolutions, therefore showed a decline in the variability in the water content as the working process was continued. On the other hand, in the large churnings the turning point was not reached until after the first observed stage of the working process. Thus, according to the observed stages, the variability in water content increased from thirty to forty-five revolutions and then decreased from forty-five to sixty revolutions, yet remained greater at sixty than at thirty revolutions.

The decrease in variability of the salt content as the working process was continued was to be expected. Being a foreign constituent of butter and added to it at, or near, the beginning of the working process, it is worked into the butter and dissolved by the water. Its distribution is naturally, extremely uneven during the early stages of the working process. Subsequent working, within practical limits, could not result in other than a more even distribution.

The curd content of butter is so small that ordinarily its variability in butter from different parts of the churn is of little concern from a commercial standpoint. Although a decrease was shown of the variability in curd as the working process was prolonged, in view of the relative crudeness of the method of analysis as compared with the slight changes noted, this change can be interpreted only as an indication.

SUMMARY

The effect of prolonged working upon the distribution of water, salt, curd, and fat in butter was studied. Samples of butter were taken from different locations within the churn at three stages of the working process, namely, thirty, forty-five, and sixty revolutions.

The composition of butter, as expressed by the variability in the fat content, became less variable as the working process was prolonged. Of the three non-fatty constituents, the curd had the least effect upon the variability in the composition of butter as a whole, while the salt exerted the greatest influence and the water the next greatest influence. The variability in the water content of small churnings decreased as the working process was prolonged; while in large churnings, an increase in variability was shown from thirty to forty-five revolutions followed by a decrease at sixty revolutions; however, the variability was greater at sixty revolutions than at thirty. A more even distribution of the salt and curd was obtained as the working process was prolonged.

REFERENCES

(1) Lee, C. E., Hepburn, H. W., and Barnhart, J. M.: A study of factors influencing the composition of butter. Illinois Agr. Exp. Sta. Bul. 137, 1909.

(2) Hunziker, O. F., Mills, H. C., and Spitzer, George: Moisture control of butter. Purdue Univ. Agr. Exp. Sta. Bul. 160, 1912.

(3) Guthrie, E. S., and Ross, H. E.: Distribution of moisture and salt in butter. Cornell Univ. Agr. Exp. Sta. Bul. 336, 1913.

BUTTER VERSUS OLEOMARGARINE IN RICKET CONTROL IN PIGS*

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The following report covers one year's experimental work in a coöperative experimental project between the Dairy Department and the Animal Husbandry of the West Virginia University and Experiment Station. This project is the more recent development of an earlier project started by these two departments in 1923 to study the vitamin A deficiency in white corn and to secure a comparative economic measurement of this deficiency by supplementing a white corn basal ration with butter, which was rich in vitamin A, and also oleomargarine commonly considered to contain lesser amounts of vitamin A. In the progress of this earlier project it was noted that when oats were fed in the basal white corn ration that the pigs did not develop rachitic symptoms at about 90 days as was commonly experienced in white corn feeding. Oats have not been previously classed by investigators as having either vitamin A, the growth promoting vitamin, or vitamin D, the anti-rachitic vitamin, in noticeable amounts. The same oat fed lots of pigs when fed butter and oleo failed in the ordinary feeding period of 90 to 100 days to show any rachitic symptoms.

This led to the development of a supplementary project in 1926, in which the basal ration used in 1923–1924–1925 was changed to a new basal ration, containing white corn, buckwheat middlings and tankage and the same mineral mixture as the original basal rations, but without oats being used. Butter and oleo were used as in the earlier project with both basal rations, 2 ounces being fed daily throughout the feeding period for each 100 pounds live weight. Table 1 shows the results of this trial.

This trial shows rather strikingly the fact that when oats were

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used in the ration that the ordinary rachitic symptoms did not develop during the ordinary feeding period of 112 days. It also further shows that when the basal ration did not contain oats that 50 per cent of each lot showed rachitic symptoms within 86 days after starting. The adding, however, of 2 ounces of butter daily per 100 pounds live weight of this same ration brought the lot

TABLE 1

Ricket control experiment with pigs, West Virginia University and experiment station

LOT NUMBER	DATE		NUMBER OF DAYS	NUMBER OF PIGS	AVERAGE INITIAL WEIGHT	AVERAGE FINAL WEIGHT	AVERAGE GAIN	AVERAGE DAILY GAIN	FEED PER 100 POUNDS GAIN	NUMBER OF PIGS GOING DOWN	NUMBER OF DAYS ON FEED BEFORE GOING DOWN
					pounds	*pounds*	*pounds*	*pounds*			
1	1926	Basal Ration I	112	4	38.5	182.5	144.0	1.29	405	0	—
2	1925	Basal Ration I with butter	98	5	46.4	169.2	122.8	1.25	387	0	—
3	1925	Basal Ration I with oleo	98	5	47.0	160.4	113.4	1.16	410	0	—
4	1926	Basal Ration II	112	4	39.3	184.7	145.4	1.29	396	2	86
5	1926	Basal Ration II with butter	112	4	39.0	197.0	158.0	1.41	386	0	—
6	1926	Basal Ration II with oleo	112	4	40.5	196.0	155.5	1.39	406	2	86

Basal Ration No. 1. White corn 500 pounds, oats 400 pounds, tankage 66 pounds, oil meal 33 pounds.

Basal Ration No. 2. White corn 300 pounds, buckwheat middlings 100 pounds, tankage 20 pounds.

Butter and oleomargarine fed 2 ounces daily per 100 pounds live weight.

Basal rations fed 5 pounds daily per 100 pounds live weight.

through 112 days feeding with no symptoms of rickets. The lot fed on the same basal ration, but with two ounces oleo daily per 100 pounds live weight, showed 50 per cent rachitic conditions within 86 days after starting.

Due to the fact that oats and butter have not been ordinarily considered to contain Vitamin D in large amounts, it was at first

questioned whether the rachitic symptoms observed were true rachitic symptoms or possibly confused with symptoms of Vitamin A deficiency. To the affected pigs in these lots, cod liver oil, both *raw* and *oxygenated*, was fed daily in amounts of 25 cc. per 100 pounds live weight. Although several of these pigs had developed well marked symptoms such as nervousness, dropping ears, off feed, wobbly walking, unable to rise, all pigs so treated, except one which died the first day of treatment, improved rapidly and were in normal market condition in 30 days after starting treatment. This seems to indicate rather conclusively that these symptoms were true rachitic ones and were held in check by either oats or butter added to the ration, but not when oleomargarine was used.

This project will be carried on again this year under the same plan, using basal ration I and II, and also using butter and oleo, but carrying all groups through breeding and farrowing to see whether the oats and butter serve as only a retarding influence on rachitic conditions or as a complete check throughout the life time feeding and activities of the pig.

It should be added that all lots were carefully balanced, being made up as near as possible from pigs from the same litter of the same age and conditions, and were given the same care and treatment throughout the entire experiment.

The oleomargarine was a nut margarine. The mineral mixture, composed of 5 pounds bone meal, 5 pounds acid phosphate, and 1 pound common salt, was uniform for all lots, and was fed at rate of 1 ounce per 100 pounds live weight daily. All lots of pigs were treated for worms before starting.

The Basal Ration I was composed of white corn 500 pounds, oats 400 pounds, tankage 66 pounds, oil meal 33 pounds, and fed 5 pounds daily per 100 pounds live weight.

The Basal Ration II was composed of white corn 300 pounds, buckwheat middlings 100 pounds, tankage 20 pounds, and fed 5 pounds daily per 100 ponds live weight.

All lots were fed and handled on comparable concrete floors and runways, and were in the sunshine. Photographs were taken of all lots at beginning and end of the trial.

A COMPARISON OF THREE METHODS OF PASTEURIZING MILK FOR CHEDDAR CHEESE-MAKING*

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Pasteurization of milk for use in the manufacture of cheese has been shown to be practicable and beneficial by Sammis and Bruhn (1912), Liska (1912), Stevenson (1923), Price (1927) and others. Various methods of pasteurizing were used by these workers. Since it is conceivable that different heat treatments of milk may affect the quality, yield and composition of the cheese produced, it is the purpose of this investigation to determine the effect on the cheese-making processes of three methods of pasteurization. These methods represent in a general way the type of heat treatments available for use in the manufacture of pasteurized milk cheese under commercial conditions.

BACTERIOLOGICAL PROCEDURE

The number of bacteria in the milk examined in this work were determined on lactose agar plates which were incubated at 37°C. for forty-eight hours. The medium used for plating had the following composition:

Peptone (Difco)	10 grams
Beef extract (Liebig)	5 grams
Lactose (C.P.)	10 grams
Agar agar	15 grams
Distilled water	1000 cc.

The reaction was adjusted to pH 7.0 and one lot only of the medium was used in making the counts from a single experiment.

Samples of milk for plating were held in cotton-stoppered, sterile test tubes which were packed in ice. The time interval between collecting and plating was never greater than four hours. Every dilution of each sample was plated in triplicate.

* Received for publication July 10, 1927.

METHOD OF CHEESE MANUFACTURE

The milk used in each experiment was placed in a 300-gallon pasteurizer and thoroughly mixed. Four portions, weighing approximately 400 pounds each, were then removed while the milk was in motion. Each lot was sampled for bacterial counts at this time. Without any unnecessary delay these lots were subjected to the following procedures:

The first portion was placed in a cheese vat and held at approximately 60°F. until the three remaining lots were ready to make into cheese.

The second portion was pasteurized by heating to 160° to 165°F. in a flash heater and then cooled immediately by means of a surface cooler. This method of pasteurization will hereafter be called the "Flash" process.

The milk of the third portion was heated in a flash pasteurizer to 145° to 150°F. and then conducted to a cheese vat where it remained until the entire lot had been so treated. It was then cooled to about 88°F. by pumping it over a surface cooler. The average time of heating was approximately twenty-two minutes. Nine minutes elapsed before the milk was pumped over the cooler due to necessary changes in sanitary piping. The temperature of the milk was not permitted to fall below 142°F. before the cooling operation was started. The entire time of cooling averaged about eleven minutes. This method of pasteurization will be called the "Flash-Holder" process.[1] It was intended to duplicate approximately the holder method of pasteurization without the relatively expensive equipment of the usual holder method of treatment.

The remaining 400 pounds was pasteurized by the well known "Holder" method. The milk was heated in a batch pasteurizer to 145°F. and held at that temperature for thirty minutes after which it was cooled to approximately 88°F.

Exactly 300 pounds of each lot of milk was weighed into each of four 50-gallon jacketed cheese vats and samples were taken for

[1] This heat treatment was developed from a suggestion made by Mr. H. Feldmeir of D. H. Burrell and Company, Inc., Little Falls, New York.

bacterial counts. Clean flavored lactic starter was added immediately to the milk in amounts varying from 1 to 3 per cent. The starter was usually about eighteen hours old from the time of its inoculation. Each vat of milk was made into the best possible cheese by the procedure described by Price (1927).

This procedure was followed as closely as possible for 10 experiments carried on between March 2 and May 25, 1926. In one experiment an accident resulted in the loss of the raw milk. The other lots were made into cheese as usual. This fact can be observed in subsequent data in the non-agreement of the differences of the mean scores and the mean differences in score between the pairs of raw and pasteurized milk cheese.

The cheese were scored to determine their quality at the ages of four and eight months. Three or more judges[2] examined the cheese. The average of their scores was taken to represent the quality of the cheese. The estimates were made on the basis that a perfect score would be: flavor, 50; body and texture, 35; color, 15; finish, 10.

The cheese and whey were analyzed for fat and total solids by the Mojonnier method (Mojonnier and Troy, 1925).

BACTERIOLOGICAL RESULTS

The bacterial counts of the raw milk ranged from 1,100,000 to 190,000,000 per cubic centimeter. The percentage of the number of bacteria in the original milk which were destroyed by the different methods of pasteurizing are shown in table 1. The averages of the percentage reduction for the Flash, Flash-Holder and Holder heat treatments are 98.31, 98.65 and 98.96 respectively.

The Holder method is apparently the most effective in reducing the bacterial count, while the Flash method allows the greatest number of organisms to survive the treatment. It is interesting to note the reduction accomplished by the Flash-Holder process.

[2] The authors are grateful for the assistance of Mr. J. C. Marquardt of the New York Experiment Station (Geneva), Dr. E. S. Guthrie and Mr. W. Hochstrasser of the New York State College of Agriculture, and Mr. A. B. Hargrave of the New York State Department of Agriculture and Markets, in scoring the cheese.

Bacterial counts were made on the lots of milk immediately after leaving the Flash heater when it was at a temperature of 145° to 150°F. These determinations show that an average of 75 per cent of the total number of organisms in the raw milk are destroyed by this exposure. An additional 23.5 per cent of the number of bacteria in the original milk are eliminated during the subsequent holding period.

It is probably true that the addition of starter to pasteurized milk in the amounts used in cheese-making establishes imme-

TABLE 1

Percentage of bacteria in original milk destroyed by the three heat treatments

EXPERIMENT NUMBER	FLASH	FLASH-HOLDER	HOLDER
1	98.91	99.35	99.09
2	99.83	99.86	99.76
3	99.83	99.77	99.89
4	99.60	97.72	99.13
5	96.48	96.80	98.00
6	99.55	99.21	98.79
7	99.89	99.91	99.93
8	96.19	97.80	98.24
9	97.90	98.42	98.37
10	94.91	97.71	98.40
Average.....	98.31	98.65	98.96

diately a predominance of organisms whose development inhibits the growth of those undesirable types which may have survived the heating process. It is therefore doubtful if the slight differences in the relative efficiencies of these heat treatments, as indicated by the percentage reduction of the numbers of organisms in table 1, are of any real significance in the manufacture of Cheddar cheese.

RESULTS OF CHEESE MANUFACTURE

Effect of pasteurization on curdmaking

The manufacture of cheese from milk pasteurized by any of these heat treatments is not unusual or difficult. The curd

resembles that obtained from very sweet raw milk of desirable quality. The only essential differences in the curd-making process are the slightly delayed coagulation in the flash heated milk and the slow acid development. The delayed coagulation can be corrected by using ½ to 1 ounce more of rennet or by setting at 88°F. instead of 86°F. as is customary. The acid development can be controlled by the addition of commercal starter.

The rate of coagulation of the four lots of milk is illustrated by the average Marshall rennet test before the addition of starter:

	Spaces
Flash	5.8
Flash-Holder	5.3
Holder	5.2
Raw	4.7

The difference between the rate of coagulation of the raw and pasteurized milk is probably due partially to increase in the acidity of the raw milk during the interval when the lots of heated milk were being subjected to their respective heat treatments. It is true however, that flash pasteurization causes a delay in the rennet coagulation

The curd produced from milk heated by the Flash method at 160° to 165°F. can be successfully handled in spite of the slower rate of coagulation. This observation of the curdmaking process in these experiments is really unnecessary in view of the general use of the flash pasteurizer in New Zealand cheese factories (Stevenson, 1923) as well as in many factories in the United States. Cheddar cheese has also been made successfully on a commercial scale from milk pasteurized by the Holder method (Price, 1927). The curd produced by this heat treatment seems to resemble raw milk curd more closely than the curd produced by either of the other two methods of pasteurizing. The curd from the milk treated by the Flash-Holder process resembles that produced from the Holder-pasteurized-milk so closely that it is usually very difficult to distinguish between them.

Effect of pasteurizaton on cheese quality

Table 2 shows the mean scores of the cheese of the 10 experiments after four months of curing at 45° to 50°F. It is evident from an examination of these figures that pasteurization of milk by any of the three methods improves the quality of the cheese when it is partially cured. As might be expected, the improvement is chiefly in the flavor.

The results shown in table 3 are emphasized when Student's method (Student, 1908) is used to interpret the significance of the differences in the total score between the pairs of raw and

TABLE 2

Mean scores of the cheese when four months old

	RAW	FLASH	FLASH-HOLDER	HOLDER
Flavor scores	36.88 ±0.49	38.64 ±0.26	38.40 ±0.35	38.50 ±0.27
Body and texture scores	23.04 ±0.15	23.25 ±0.07	23.36 ±0.07	23.34 ±0.07
Total scores	84.61 ±0.57	86.49 ±0.42	86.62 ±0.40	86.46 ±0.45

TABLE 3

Mean gain in total scores of pasteurized milk cheese over raw milk checks at four months of age

HEAT TREATMENT	GAIN IN SCORE	SIGNIFICANT ODDS
Flash	1.91	908 to 1
Flash-Holder	2.00	555 to 1
Holder	1.94	555 to 1

pasteurized milk cheese. The advantages of this treatment of this type of data are discussed by Love and Brunson (Love and Brunson, 1924). Love's tables (Love, 1924) have been used in conjunction with Student's formula.

From table 3 it is apparent that the improvement in the quality of the cheese due to pasteurizing by any of the three methods tried is practically the same when the cheese are four months of age.

After eight months in the curing room at temperatures ranging from 45° to 55°F. the quality of the cheese is indicated by the average scores of table 4. Here again, as at four months of age,

the flavor of the cheese shows the greatest improvement, due to the heat treatments to which the milk was subjected.

Table 5 shows the average gain in total score, at eight months of age, of the pasteurized milk cheese when compared with the raw milk cheese made from identical raw material. The significant odds are calculated by Student's formula.

Tables 4 and 5 indicate that the Flash treatment is not quite so

TABLE 4

Mean scores of the cheese when eight months old

	RAW	FLASH	FLASH-HOLDER	HOLDER
Flavor scores	37.83 ±0.37	39.26 ±0.38	40.17 ±0.38	40.01 ±0.31
Body and texture scores	23.10 ±0.12	23.31 ±0.07	23.51 ±0.11	23.36 ±0.11
Total scores	85.47 ±0.37	87.16 ±0.33	88.31 ±0.43	88.01 ±0.38

TABLE 5

Mean gain in total scores of pasteurized milk cheese over raw milk checks at eight months of age

HEAT TREATMENT	GAIN IN SCORE	SIGNIFICANT ODDS
Flash	1.89	212 to 1
Flash-Holder	3.12	1999 to 1
Holder	2.70	4999 to 1

TABLE 6

Cheese from 100 pounds of milk and starter

RAW	FLASH	FLASH-HOLDER	HOLDER
pounds	*pounds*	*pounds*	*pounds*
9.92 ±0.16	10.18 ±0.16	10.18 ±0.16	10.32 ±0.17

effective as the other two heat treatments in improving the quality of the cheese after aging for eight months. The Flash-Holder and Holder treatments show an even greater gain in score over the raw milk check than was apparent at four months of age. The difference in score between the cheese from Flash-Holder and Holder treated milk is too small to be of any significance.

It is apparent from these scores obtained from the cheese during the curing process that each method of pasteurization improves

the quality of the cheese, and that the Flash-Holder and Holder methods of treating the milk cause the greater improvement in quality during the life of the cheese.

Yield and composition

The cheese was removed from the press on the day after it was made and weighed and sampled for fat and total solids tests. The average yield of the cheese is given in table 6.

TABLE 7

Average composition of the cheese

MATERIAL	RAW	FLASH	FLASH-HOLDER	HOLDER
	per cent	*per cent*	*per cent*	*per cent*
Fat	34.37 ±0.37	33.51 ±0.25	33.19 ±0.24	33.11 ±0.30
Solids-not-fat	28.53 ±0.22	28.30 ±0.25	28.56 ±0.30	28.55 ±0.19
Moisture	36.88 ±0.26	38.18 ±0.37	38.24 ±0.34	38.34 ±0.32

TABLE 8

Fat, solids-not-fat, and moisture in the cheese

MATERIAL	RAW	FLASH	FLASH-HOLDER	HOLDER
	pounds	*pounds*	*pounds*	*pounds*
Fat	3.41	3.40	3.37	3.41
Solids-not-fat	2.83	2.87	2.91	2.94
Moisture	3.67	3.90	3.90	3.97

TABLE 9

Average composition of the whey

MATERIAL	RAW	FLASH	FLASH-HOLDER	HOLDER
	per cent	*per cent*	*per cent*	*per cent*
Fat	0.386 ±0.018	0.344 ±0.017	0.368 ±0.017	0.370 ±0.016
Milk-solids-not-fat	6.43 ±0.06	6.35 ±0.07	6.37 ±0.07	6.40 ±0.06

The cheese made from the Flash and Flash-Holder treated milk show a gain of approximately 0.25 pound, which represents 2.5 per cent of the weight of the raw milk cheese obtained from the same amount of milk and starter. The Holder method heat treatment shows a gain in yield of 4 per cent. Such gains, which

are in harmony with the results of previous work (Sammis, 1912; Price, 1927), tend to offset the cost of processing the milk.

Analysis of the cheese brings out the fact that the increase in the yield of the pasteurized milk cheese is due largely to increase in its moisture content, as shown in table 7. This is further substantiated by the data of table 8 which shows the average pounds of fat, solids-not-fat, and moisture retained in the cheese from 100 pounds of milk and starter.

Analysis of the whey (table 9), at the time of dipping tends to demonstrate that in these experiments the increased yield of the pasteurized over the raw milk cheese is probably not due to the greater retention of fat and milk-solids-not-fat.

The differences noted in table 9 are too small to be considered significant for the number of observations. Other experiments (Sammis, 1912; Stevenson, 1923; Price, 1927) have shown that the slight tendency exhibited in these figures for the pasteurized milk cheese to lose less fat in the whey is to be expected under ordinary conditions.

APPLICATION OF THE RESULTS

The three methods of pasteurization, whose effect upon the process of Cheddar cheese manufacture are discussed here, suggest means by which any cheese factory can improve the quality of cheese produced. These treatments should prove especially valuable where milk of inferior quality must be made into cheese. The significant result of this work is the general improvement in the quality and yield of the cheese following the use of all the methods of pasteurizing. It is not intended to attempt to demonstrate here the other advantages which result from the pasteurization of milk for cheese making. The greater uniformity of the product and the improved keeping quality, as well as other facts, have been pointed out by those whose experiments and practical experiences with pasteurization have been previously mentioned in this discussion.

SUMMARY

1. Milk pasteurized by any of the three heat treatments described produced higher scoring cheese than identical milk not pasteurized.

2. No calcium chloride or hydrochloric acid was necessary to stimulate rennet coagulation.

3. The Flash method of pasteurizing was not so effective as the other heat treatments.

4. The yield of cheese from pasteurized milk was increased from 2.5 to 4 per cent in excess of the yield obtained from identical milk not pasteurized, due to the retention of more moisture.

REFERENCES

BENSON, M., AND EVANS, R. H. 1913 The manufacture of cheese from "heated" milk. Jour. Board Agriculture (Great Britain), xx, no. 4, 281–301.

LISKA, A. 1912 Käsefabrikation aus pasteurisierter Milch. Milchwirtshaftliches Zentralblatt, xli, no. 16, 481–485.

LOVE, H. H., AND BRUNSON, A. M. 1924 Students method for interpreting paired experiments. Jour. Amer. Soc. Agron., xvi, no. 1.

LOVE, H. H. 1924 A modification of Student's tables for use in interpreting experimental results. Jour. Amer. Soc. Agron., xvi, no. 1, 68–73.

MOJONNIER, T., AND TROY, H. C. 1925 The Technical Control of Dairy Products. Mojonnier Brothers Company, Chicago, Ill., pages 95–131.

PRICE, W. V. 1927 Cheddar cheese from pasteurized milk. Jour. Dairy Sci., x, no. 2, 155–168.

SAMMIS, J. L., AND BRUHN, A. T. 1912 The manufacture of cheese from pasteurized milk. Wisc. Expt. Station Res. Bul. 27.

STEVENSON, C. 1923 Pasteurization of milk for Cheddar cheese-making in New Zealand. Proceedings of the World's Dairy Congress, 1923, i, 306–308.

"Student" 1908 The probable error of a mean. Biometrika, vi, 1–25.

THE POSSIBLE TOXICITY OF BUTTERMILK SOURED IN ZINC CONTAINERS*

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The general impression has long been held that zinc salts are toxic to man and animals. In the past there have been instances where foods, prepared or stored in zinc-lined vessels, were thought to have caused illness among persons comsuming them.

In the spring of 1925, farmers in an Oklahoma community attributed a number of deaths among swine to the feeding of buttermilk held in a galvanized iron tank. They suspected that zinc dissolved from the lining of the tank, was the cause of the trouble. These facts, brought to the attention of the Oklahoma Agricultural Experiment Station, led to the following investigation to determine whether zinc had been the chief contributing factor.

PREVIOUS INVESTIGATIONS

A review of the literature reveals interesting data regarding the possibility of zinc poisoning among men and animals.

Barnard and Bishop (1) found that lemonade stored in a zinc container dissolved an appreciable amount of zinc. The Indiana State Board of Health, under whose auspices this investigation was conducted, declared unlawful the further use of zinc-coated containers for the manufacture and storage of acid drinks.

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Seiffert (2) reported on metallic zinc poisoning as follows:

> The damage due to zinc is underestimated. Zinc dust is swallowed and passes into the gastrointestinal canal. Continual, even though slight absorption of zinc, gradually produces illness. The greatest damage is done by the dusts of blende and calamine, which contain large amounts of zinc sulphate and zinc carbonate. Chronic zinc poisoning in workmen in zinc smelters cannot be denied. In fact it is the chief cause of the occupational disease of that industry.

Similar published reports are common.

Since this inquiry began, a series of publications of the Department of Physiology of the Harvard School of Public Health, leads one to question many previous investigations, and suggests that some of the earlier investigators may have erred in their conclusions, and that where poisoning occurred, it may possibly have been due to contamination with arsenic, lead or antimony off the galvanized surfaces rather than to the zinc.

Batchelor, Fehnel, Thomson and Drinker (3) have shown that men in contact with zinc metal suffered no disturbances as a result. Lutz (4) and Drinker and Collier (5) reported that zinc was a normal constituent of certain parts of the human body, was present in most foods, and in all probability performed a useful function in metabolism.

Recently we reported (6) that rats fed a complete ration to which zinc, or zinc salts, were added up to 0.25 per cent of the food consumed, suffered no unfavorable effects. Histological examination failed to reveal any pathological conditions. Analyses showed no appreciable increase in the content of zinc in the heart, liver, kidneys, spleen, lungs and testicles of these rats.

EXPERIMENTAL

The problem regarding the possible toxicity of buttermilk held in zinc storage vat, divides itself into two phases, analytical and biological; i.e., is the zinc content of the buttermilk increased through contact with zinc-lined vessels, and does such alteration render this buttermilk harmful to rats and swine?

In attempting to answer the first question, quantitative analy-

ses were made for the zinc content of cultured buttermilk soured in glass containers, in new, and in old zinc pails, held for various lengths of time, and at various temperatures. The zinc content of commercially churned buttermilk obtained from a creamery where it has been stored in a galvanized storage vat, was also determined.

METHOD OF ANALYSIS

The milk was placed in an evaporating dish and heated to boiling, then transferred to a vacuum oven until dry. It was then transferred to a muffle furnace and heated six hours at black heat. The black product resulting was extracted with hydrochloric acid

TABLE 1

Effect of containers on the zinc content of commercial and cultured buttermilk

SOURCE AND KIND OF SAMPLE	ZINC PER 1000 CC. OF SAMPLE	ACIDITY OF SAMPLE
	mgm.	*per cent*
Fresh milk	3.5	0.17
Buttermilk cultured in glass containers	3.5	0.80–0.9
Commercial buttermilk from old galvanized tank	7.0	0.80–0.9
Cultured buttermilk in new galvanized pail held twenty-four hours	150.0	0.80–0.9
Held four days	200.0	0.80–0.9

and filtered, and the process repeated, dampening with nitric acid until completely extracted. The acid filtrate was analyzed by the Birckner (7) method. This method, briefly stated, consists in adjusting the hydrogen ion concentration so that the solution when treated with hydrogen sulfide precipitates the zinc and leaves the iron in solution The sulfide is well washed and dissolved in dilute hydrochloric acid. Aliquot parts of this solution were placed in Nesslerizing tubes and treated with potassium ferrocyanide. The resulting turbidity was compared with a series of standard zinc solutions, simultaneously prepared and treated.

Better results were obtained by first removing the iron by the basic acetate method and then proceeding as directed. This step overcomes the difficulty of completely removing all the iron, as

was recommended in the original Birckner method. The results of the analyses confirmed the report of Birckner (7) that normal milk contains zinc. It further demonstrated that the milk dissolved additional zinc from the container, as an inspection of the surface had indicated previously. Further, it was found that the zinc content increased with length of time of storage, with increased temperatures, with the acidity of the buttermilk, and with newness of the containers. It is probably that some of these effects overlap in results reported here. An average set of analyses illustrating these facts, is given in table 1.

BIOLOGICAL TESTS WITH RATS

Rats and swine were used as experimental animals. The rats being used in larger numbers served as a check and also to verify the effects obtained on a very limited number of swine. Albino rats were chosen from the stock colony of the department of agricultural Chemical Research, the normal growth curve, age of reproduction, and size of litters of which had been established. They were fed the following basal ration:

Yellow corn, ground	50
Whole wheat, ground	41
Tankage	5
Sodium chloride	1
Calcium carbonate	1
Cod liver oil	2

The rats were divided into six lots, with respect to age, size and parentage, and placed in round metal cages. The basal ration was supplemented with buttermilk and zinc salts as shown in table 2.

Reports in the literature led us to expect deleterious effects with all rations containing zinc. Our experimental animals showed few serious effects from these rations. Details concerning relative growth and reproduction are summarized briefly in table 3.

It is observed that Lot II receiving buttermilk at will, grew better and had larger litters than those receiving the basal ration only. Lot III likewise grew above the normal rate, produced

young, and even the second and third generations produced young without exhibiting any deleterious effects from the ration employed. Lot V also made fair growth, and reproduced, though a larger proportion of their offspring died. Lot VI made poor growth, and failed to reproduce. After several weeks they showed loss of appetite, the hair became rough, and they suffered

TABLE 2

Experimental rations received by rats

LOT	SUPPLEMENT RECEIVED IN ADDITION TO BASAL RATION
I	None
II	Buttermilk soured in glass, ad libitum
III	Buttermilk soured in new zinc pail, ad libitum
IV	Buttermilk from old galvanized tank, ad libitum
V	0.5 per cent of ration as zinc lactate
VI	1.0 per cent of ration as zinc carbonate

TABLE 3

LOT	SUPPLEMENT	MALES	FEMALES	LITTERS YOUNG	YOUNG LIVED	YOUNG DIED	GROWTH
I	None	2	2	3	18	3	++++
II	Buttermilk soured in glass	2	2	3	23	2	+++++
III	Buttermilk soured in new zinc pails	4	6	7	48	3	+++++
IV	Buttermilk from old zinc tank	2	2	4	28	1	+++++
V	0.5 per cent zinc lactate	2	2	2	9	4	++++
VI	1.0 per cent zinc carbonate	2	3	0	0	0	++

from diarrhea. They were retained far beyond the period of sexual maturity, but did not reproduce.

These results lead one to conclude that the amounts of zinc ordinarily found in food contamination, may have little or no harmful effects. It is only when the zinc salt is increased to abnormal amounts that growth and reproduction are affected. Such amounts are seldom found in food under ordinary conditions.

BIOLOGICAL TESTS WITH SWINE

Eight Hampshire gilts of similar breeding, each weighting approximately 100 pounds, were obtained by the Dairy Department for use in a feeding trial. These animals were divided into four lots of two animals each, and placed in four separate pens on February 1, 1926. Each pen was 12 by 14 feet, and was provided with a concrete runway 12 by 16 feet which gave the animals access to sunlight and permitted some exercise. Wheat straw was used as bedding, and was replaced as needed. The following spring, they were moved to more spacious quarters, having access to unsurfaced exercise lots.

TABLE 4

Rations consumed by experimental swine

LOT	NUMBER OF GILTS	SUPPLEMENTS ADDED TO BASAL RATION
I	2	Tankage from February 1 to April 12, 1926. On April 13, buttermilk containing 0.5 to 1.0 per cent of commercial zinc carbonate, was fed. Zinc carbonate was discontinued on May 11, 1926
II	2	Plain buttermilk
III	2	Buttermilk from a galvanized iron tank in a commercial creamery
IV	2	Cultured buttermilk held from twelve to forty-eight hours in new galvanized iron pails

The basal ration fed to all lots, consisted of yellow corn and alfalfa hay, varied in amount according to appetite, rate of growth, and general thriftiness. Fresh water and salt were always available. Some fresh grass was fed in season, replacing the alfalfa hay.

In addition to the basal ration, each lot received buttermilk, or tankage, or tankage supplemented with zinc salts, as shown in table 4.

The feeding trial began on February 1, 1926 and continued until after farrowing with all animals except those in Lot I, which were discontinued on September 13, 1926.

DISCUSSION OF RESULTS

Pen I

The two gilts in Pen I constituted the control lot. They received yellow corn, alfalfa hay and tankage in addition to salt and water. They made normal gains, as would be expected. On April 13, 1926, tankage was withdrawn, and replaced with buttermilk to which 0.5 to 1.0 per cent of commercial zinc carbonate had been added. For two weeks they drank this product with apparent relish. It was then noticed they began to prefer water to the treated buttermilk. Shortly thereafter, the smaller gilt exhibited increasing stiffness of the hind legs. Whether this was due to the zinc carbonate to lack of exercise, to a shortage of minerals in the diet, or to a rheumatic condition caused by being continually on concrete floors, was undetermined. However, it is well to note that repeated veterinary examinations failed to disclose definite symptoms of zinc poisoning. Zinc carbonate was withdrawn from the ration on May 11, 1926, and the animal permitted free access to grass and to bone phosphate, while cod liver oil was added to her ration. For awhile she appeared less animated, and seemed somewhat in pain, but continued to show slow gains in weight. When returned to the Animal Husbandry department on September 13, 1926, this animal still exhibited some stiffness of the hind legs. The pen-mate was unaffected. Both animals were pregnant. It is therefore not apparent whether zinc carbonate played any part in the observed pathological condition.

Pen II

The gilts in Pen II received the basal ration plus plain buttermilk. This buttermilk was the product made from churning cream that had been neutralized to approximately 0.3 per cent acidity at the churn, or was cultured in tinned containers from separator-skimmed milk. Both gilts made satisfactory gains in weight. On September 4, 1926, the first gilt farrowed one dead and four living pigs, healthy and normal. The second gilt was bred repeatedly, finally farrowing one dead and nine live pigs on July 22, 1927. These were of good size and active.

Pen III

The gilts in Pen III received the basal ration plus buttermilk obtained from the churning of neutralized cream in a commercial creamery. This buttermilk was pumped from the churn directly to a large galvanized iron storage tank and held twelve to twenty-four hours before being drawn off by creamery patrons and taken to the farms there to be fed to hogs. Through the courtesy of the creamery, regular shipments of this buttermilk were obtained for use in the feeding trial.

TABLE 5

Record of farrowing of experimental swine

LOT	SUPPLEMENT USED (CONTROL SOWS LATER RECEIVING)	SOW	DATE OF FARROWING	NUMBER OF PIGS		AVERAGE WEIGHT OF PIGS	WEIGHT OF SOW AFTER FARROWING
				Live	Dead		
						pounds	*pounds*
I	Zinc carbonate as in table 4	1	Pregnant	Withdrawn September 13, 1926			327
		2	Pregnant				276
II	Plain buttermilk	3	September 4, 1926	4	1	2.29	328
		4	July 22, 1927	9	1	2.78	434
III	Buttermilk from zinc storage vat	5	February 25, 1927	10	1	2.67	419
		6	September 2, 1927	6	0	2.70	537
IV	Buttermilk soured in galvanized pails	7	December 21, 1926	9	0	3.39	449
		8	May 31, 1927	5	0	3.47	480

Both gilts came in heat normally, and were bred. On February 25, 1927, the first sow farrowed one dead and ten live pigs that appeared normal but were somewhat weak. The second sow was served seven times. She finally became pregnant, and farrowed six live pigs on September 2, 1927.

Pen IV

Two pigs in Pen IV received the basal ration plus buttermilk soured in galvanized iron pails of 14 quart capacity. This butter-

milk was made by allowing skim milk to stand at room temperature for twelve to forty-eight hours. New pails were purchased and used as frequently as the zinc coating appeared to be dissolved from the inner surface of the pail. Both gilts came in heat normally and were bred. On December 21, 1926, the first sow farrowed nine live, healthy pigs, all of good size except one. The second sow, after repeated breeding, conceived and farrowed five healthy pigs on May 31, 1927.

Since data were desired only as to the effect of the zinc in the buttermilk upon the sows themselves, and upon their ability to reproduce, each animal was withdrawn from the trial immediately after farrowing. No indication was noted that the zinc dissolved from zinc-lined containers by buttermilk, had any effect upon the sows themselves, nor upon the size and vigor of the offspring. The delay experienced in getting some of the animals to conceive, may or may not have been due to the degree of fatness of the animals at time of breeding. It appears that such may have been the same, since this difficulty was experienced with one animal in each of the last three lots.

DISCUSSION OF RESULTS

Several factors are worthy of note before any conclusions are drawn. In the first place, we acknowledge that our facilities were too limited to permit a larger number of swine to be used in this phase of the work, but believe that the data obtained from them, together with that secured from the feeding trials with rats, are sufficient to be of value in throwing some light upon the possible toxicity of the buttermilk held in zinc-coated equipment, and of the zinc compounds used.

It was necessary to re-breed several of the gilts, one as many as seven times, before they became pregnant. Doubtless the boars were not at fault, since they rendered satisfactory service with other animals in the regular college Hampshire herd. Since as much difficulty was experienced with Lots II and III as with Lot IV which received the buttermilk containing the largest amounts of zinc, as shown in table 1, it is thought by the authors that the failure to conceive readily was not caused by the zinc, but

possibly by the excessively high fat condition of the animals receiving such a good ration, or to a lack of sufficient exercise. The feeding trial was begun with gilts weighing approximately 100 pounds. As far as health and reproduction are concerned, the buttermilk soured in zinc containers appeared to have no marked effect, *with animals of this size.*

Attention should also be called to the fact that the gilts in Lots I and IV were fed buttermilk containing dissolved zinc in much greater quantities than would ever be given under ordinary conditions. Therefore, in the light of the results obtained with both rats and swine, the following conclusions seem warranted.

CONCLUSIONS

1. Buttermilk dissolves the zinc from the surface of galvanized vessels in proportion to (*a*) acidity of the buttermilk, (*b*) area of surface exposed per unit of buttermilk present, and (*c*) time of exposure.

2. Small amounts of zinc lactate such as might be found in food appear to have no marked effect upon growth and reproduction of rats and swine.

3. A relatively large amount of zinc corbonate (1 per cent or more) appears to retard growth and reproduction of rats. The exact nature of the injury in not entirely evident.

4. It would appear that buttermilk soured in galvanized containers has no deleterious effect upon growth and reproduction of rats and swine, under the conditions of this experiment.

REFERENCES

(1) Barnard, H. E., and Bishop, H. E.: Indiana State Board of Health Report, 1908, 254.
(2) Seiffert: Chem. Zentr., 1918, ii, 305; Chem. Abstr., 1920, xiv, 980.
(3) Batchelor, R. G., Fehnel, J. W., Thompson, R. M., and Drinker, K. R.: Jour. Ind. Hyg., 1926, viii, 322.
(4) Lutz, R. E.: Jour. Ind. Hyg., 1926, viii, 177.
(5) Drinker, K. R., and Collier, E. S.: Jour. Ind. Hyg., 1926, viii, 257.
(6) Heller, V. G., and Burke, A. D.: Jour. Biol. Chem., 1927, lxxiv, 85.
(7) Birckner, V.: Jour. Biol. Chem., 1919, xxxviii, 191.

INFLUENCE OF TEMPERATURE ON THE CHANGES PRODUCED IN MILK BY CERTAIN BACTERIA*

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INTRODUCTION

The changes brought about in various materials by bacteria are extremely important in the study of these organisms. Certain of them are investigated chemically in an attempt to explain the source of various products formed, while those that can be readily detected are widely used in the identification of organisms.

Milk may undergo a variety of changes because of the number of constituents it contains which are easily broken down; some of these changes, especially those in the casein, are very conspicuous. Milk is, therefore, a valuable medium for use as an aid in identifying certain organisms and is widely employed for this purpose.

Observations made at various times indicated that with certain organisms the temperature at which growth occurred had an influence on the type of change brought about in milk. An attempt was accordingly made to determine with what organisms there was such an effect, and also whether or not it was pronounced enough to be given consideration; the results secured are reported herein.

GENERAL PROCEDURE

In the study of the influence of temperature on the changes brought about in milk by bacteria the only temperatures used were room temperature and 37°C. Tubes of milk from the same lot were inoculated, using approximately equal amounts of inoculating material, and some held at room temperature and the others at 37°C.; observations on the changes occurring were then made at various intervals over a rather extended period. The

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rate of change at the two temperatures was also studied in a general way by means of acid and soluble nitrogen determinations and some attention was given to the numbers of organisms present.

METHODS

The lots of milk studied were held in test tubes in quantities of about 10 cc. When a given determination was run on different days new tubes were used each time.

Acid determinations. The acid determinations were made by titrating a measured portion of the milk, usually 5 cc., with N/20 NaOH using phenolphthalein, and calculating as lactic acid.

Soluble nitrogen determinations. The soluble nitrogen was separated by measuring a small volume of the milk, usually 5 cc., into a beaker, adding water and a few drops of glacial acetic acid and then filtering. Nitrogen determinations were run by the Kjeldahl method on both the soluble and insoluble portions, so as to provide data for a check on the total amount of nitrogen.

Bacterial counts. The bacterial counts were run by the plate method. Whey agar was used for the true lactic acid organisms and the standard agar for milk analysis for the other types; the incubation was forty-eight hours at 37°C. in all cases.

Sampling. Before sampling flocculated or curdled material for various purposes it was broken up and distributed as uniformly as possible by means of a sterile glass rod.

RESULTS OBTAINED

The organisms studied may conveniently be divided into two groups, (1) those belonging to the lactic acid bacteria and attacking principally the lactose, and, (2) those belonging to the proteolytic types and having their conspicuous action on the casein. The former may be separated into (*a*) the true lactic acid organisms and (*b*) the gas forming lactic acid organisms.

1. Lactic acid bacteria

a. True lactic acid organisms. There was no evidence that temperature had an effect on the type of the change produced in

milk by the true lactic acid bacteria but certain of these were nevertheless investigated.

Streptococcus lactis. Two typical S. lactis cultures were studied, and with both of them there was no observable difference in the type of change produced in litmus milk at room temperature and at 37°C. The reduction, coagulation and return of the color proceeded in essentially the same manner in both cases. At 37°C. definite reduction of the litmus and the subsequent changes occurred much more quickly than at room temperature, as is usually the case with S. lactis cultures, although there are certain ones with which the changes at 37°C. are slower than at room temperature and some with which there is no growth at 37°C. Covering the surface of the milk with nujol to limit the oxygen supply had no definite influence on the changes produced in milk by the organisms.

Determinations of the acidity at various intervals showed that, with the cultures studied, acid was produced much more rapidly at 37°C. than at room temperature during the early part of the holding period, but that later the acidity was higher at room temperature. The differences between the acidities eventually developed at the two temperatures were not large but were obtained regularly. This is in agreement with unreported data previously secured at the Iowa Agricultural Experiment Station with a larger number of S. lactis cultures. It would be expected that with the organisms growing so well at the two temperatures, the acid developed would have more of an inhibiting effect at the higher temperature. No increase in the amount of soluble nitrogen in milk in which the organisms had grown was noted at either temperature.

Bacterial counts showed that the decrease in the number of organisms following the increase during the period of active growth occurred more quickly at 37°C. than at room temperature.

Lactobacillus bulgaricus. The L. bulgaricus culture studied grew very slowly in litmus milk at room temperature and very rapidly at 37°C. so that the variation in the effect of these two temperatures on the rate of change with this organism was pronounced. The general character of the changes at the two

temperatures was the same, however, and cultures at room temperature had the appearance of cultures in the same stage of development at 37°C. When the surface of the milk was covered with nujol, growth was essentially the same as when the oxygen supply was not limited.

The total acidity produced, even after a number of days, was always much lower at room temperature than at 37°C. No increase was noted at either temperature in the soluble nitrogen in the milk in which the organism had grown.

The decrease in the number of organisms following the active increase occurred more quickly at 37°C. than at room temperature.

Lactobacillus casei. The L. casei culture studied grew much less rapidly at room temperature than at 37°C., but the changes in litmus milk were essentially the same at the two temperatures, and involved reddening and reduction of the litmus, and coagulation. Flooding the surface of the milk with nujol had no definite effect on the rate or type of change produced in milk by L. casei.

The total acidity developed in milk, even after six days incubation, was considerably higher at 37°C. than at room temperature; at the former temperature the acid production was especially rapid during the first two days. No increase in the soluble nitrogen was noted as a result of the growth of the organism in the milk.

The bacterial counts showed that both the increase and the decrease following it were more rapid at 37°C. than at room temperature.

b. Gas forming lactic acid organisms. The preliminary observations suggested that temperature had only a slight effect on the changes produced in milk by the gas forming lactic acid organisms; however, two species belonging to this group were studied.

Aerobacter aerogenes. The culture of A. aerogenes used was isolated from the mouth of a cow. At room temperature sliminess developed in litmus milk in from six to seven hours and increased with age; the litmus was soon reddened. Gas bubbles were noted and were greatly increased in numbers when the tubes were jarred. The slimy material became very conspicuous

at the surface and appeared as a definite layer, while beneath it the casein seemed to separate out slightly. Later the sliminess decreased and there was a reduction of the litmus which gave the cultures a white appearance. At 37°C. growth occurred more quickly, as judged by the development of sliminess and the reddening of the litmus. Gas was soon evident also. There seemed to be a more definite separation of the casein than at room temperature and sometimes even the suggestion of a firm curd. Reduction of the litmus occurred sooner than at room temperature but the sliminess was never so pronounced. Covering the surface of the litmus milk with nujol to limit the air supply seemed to slow up the changes at both temperatures but did not influence their general character.

Although the results were not uniform, in general acid was produced in milk more rapidly and in larger amounts at 37°C. than at room temperature, while at both temperatures the limiting of the oxygen supply favored acid production. The soluble nitrogen values found showed that there was no definite change in the amount of soluble nitrogen in milk in which the organism had grown.

The bacterial counts indicated that the decrease in the number of organisms following the increase occurred sooner at 37°C. than at room temperature.

In general growth seemed to be more rapid at 37°C. than at room temperature and there was more of a tendency toward the formation of a definite curd. Sliminess seemed to be favored by the lower temperature but was pronounced at both.

Aerobacter oxytocum. The culture of A. oxytocum used was isolated from a sample of gassy cheddar cheese. At room temperature gas formation and reddening of the litmus were evident in litmus milk in about twelve hours, while after twenty-four hours gas was present in large amounts. Reduction of the litmus began after four or five days and was almost complete in from seven to ten days. Usually there was only a suggestion of coagulation and no definite curd was formed. Often there was some development of sliminess. At 37°C. gas formation and reddening and reduction of the litmus occurred more quickly than at room tem-

perature. Later coagulation took place and was much more definite than at room temperature; the curd often showed fissures through which gas had escaped. With age the curd became tough and rubbery. Sliminess was sometimes noted but was not as pronounced as at room temperature. Limiting the oxygen supply by covering the surface of the milk with nujol seemed to decrease the rate at which the organism brought about changes at either temperature.

Determinations showed that acid production started off more rapidly at 37°C. than at room temperature but that the higher acidities were reached at the latter temperature. The use of nujol at the surface of the cultures had no definite effect on the acid production. No change was noted at either temperature in the soluble nitrogen in milk in which the organism had grown.

Bacterial counts indicated that the decrease in the numbers of organisms following the increase during active growth occurred more quickly at 37°C. than at room temperature.

The principal difference in the changes in milk at room temperature and at 37°C. was in the coagulation, a definite curd being formed at the latter temperature but not at the former. There was an abundance of gas at both temperatures but the sliminess was more pronounced at room temperature.

2. Proteolytic types

The preliminary observations suggested that temperature had a rather definite effect on the type of change produced in milk by some of the proteolytic organisms and accordingly a number of these were studied.

Staphylococcus cremoris-viscosi. The culture of Staph. cremoris-viscosi studied came originally from an outbreak of ropy milk on an Iowa farm.[1] In litmus milk at room temperature ropiness was evident in from seven to nine hours and increased with age. After about sixteen hours a clear layer of viscous material developed at the surface and then later there was a suggestion of a flocculation of the casein. The precipitated casein soon began to

[1] Jour. Dairy Sci., iii, 291, 1920.

digest near the surface. The flocculation and digestion continued until there was a distinct layer of curd in the bottom with a clear liquid above. With the appearance of a definite change in the casein the ropiness disappeared entirely. At 37°C. milk cultures became ropy in from six to ten hours. After about twenty-four hours there was definite coagulation with a thin film of clear slightly ropy material at the surface. The increase in the depth of the clear surface portion suggested digestion; the clear portion soon lost its viscosity. A considerable mass of curd remained in the lower portion of the tubes even after very long holding periods. Often the curd remained attached to one side of the tube, as it decreased in amount, instead of collecting at the bottom. Limiting the oxygen supply by flooding the milk with nujol greatly decreased the rate of change in litmus milk at both temperatures but had comparatively little influence on the type of change.

Acid determinations were made at frequent intervals on cultures grown at room temperature and at 37°C., both with and without nujol. The results showed that acid development was lower at room temperature than at 37°C. and also slower under nujol than when exposed. In no case, however, was the acidity sufficient to cause coagulation. Comparisons were made of the soluble nitrogen in cultures grown at room temperature and at 37°C. for varying periods and a greater amount was regularly found in the room temperature cultures. This agrees with the general appearance of the cultures developed at the two temperatures.

Bacterial counts showed that the organisms reached their maximum numbers much more quickly at 37°C. than at room temperature and that after several days there was a pronounced decrease at 37°C., while at room temperature the decrease was only slight.

The principal difference in the action of the organism on milk at the two temperatures was a more conspicuous digestion at room temperature and a much more definite curd formation at 37°C. It was found that the temperature effect was definite and independent of the age of the inoculating material or the temperature at which it had been grown.

Pseudomonas fluorescens. At room temperature litmus milk cultures showed no change during the first twenty-four hours but during the next twenty-four hours there was a definite clearing at the surface. The digestion increased with age from the surface downward and there was some settling out of the casein but this material also digested and eventually the entire material was quite clear. The change in the color of the litmus suggested a decrease in the acidity, and there was some reduction beginning at the bottom. Usually a dry pellicle developed at the surface of the cultures. At 37°C. digestion was evident at the surface in twenty-four hours, while in the lower portions of the tubes there was some flocculent coagulation. Digestion continued and involved this floccuent material, although there remained a small amount of curd in the bottoms of the tubes even after six or seven days. By limiting the oxygen supply with a layer of nujol the rate of digestion was greatly decreased at both temperatures.

Determinations showed that acid production in milk was somewhat slower at room temperature than at 37°C. and that it was slower at both temperatures when the milk was covered with nujol than when it was exposed. In all cases, however, the acidity remained very low. Comparisons of the soluble nitrogen in cultures grown at room temperature and at 37°C. for varying lengths of time showed a tendency toward more soluble nitrogen at 37°C. early in the holding period, while later the differences were negligible. This is in agreement with the observations that digestion was pronounced at both temperatures, although it started off more rapidly at 37°C.

Bacterial counts showed the same general numbers of organisms at the two temperatures.

With Ps. fluorescens the conspicuous change in milk at either room temperature or 37°C. was a digestion. Coagulation was rather indefinite but at 37°C. there was more of a tendency toward a flocculation of the casein and a settling out of a mass of curd than at room temperature.

An enzyme preparation was made by transferring some of the clear digested material from a milk culture grown eight to ten days at room temperature to a sterile test tube, adding $CHCl_3$

and stoppering the tube; the mixture was frequently shaken during a holding period of several hours at room temperature. When this preparation was added to sterile milk in the ratio of one to ten, it caused a digestion at either temperature, without flocculation or reduction of the litmus; after six or seven days digestion was practically complete. Both microscopic examinations and transfers to agar slopes failed to show the presence of organisms.

Proteus vulgaris. With the culture studied growth at room temperature was comparatively slow. Digestion began at the surface after several days and progressed downward; when digestion was almost complete a small amount of material had settled out. The color of litmus milk changed to a yellowish brown which darkened with age. At 37°C. reduction of the litmus began in about twenty-four hours and in about thirty hours there was a layer of digested material at the surface. Beneath the digested area the milk developed a slight flocculation of the casein. Digestion of this material took place until there was only a slight sediment and the milk had a light brown color. When the oxygen supply was limited by covering the surface of the milk with a layer of nujol, the rate of growth was decreased at both temperatures, but there was no influence on the type of change.

Acid determinations at various intervals on milk in which the organism was growing showed a slight increase in acid and then a decrease. In general the increase was less and the decrease went to a lower point at 37°C. than at room temperature. Flooding with nujol resulted in a higher acidity and a smaller decrease at both temperatures. Determinations of the soluble nitrogen after various growth periods showed that an increase began more quickly and was slightly more pronounced at 37°C. than at room temperature.

Bacterial counts indicated no very striking differences in the numbers of organisms at the two temperatures during the period of examination.

With P. vulgaris as with Ps. fluorescens coagulation was not conspicuous at either room temperture or 37°C. but there was more of a tendency to a flocculation of the casein at the latter temperature than at the former.

Bac. ichthyosmius.[2] The culture used was isolated from a can of fishy evaporated milk.[3] At room temperature there was a very soft curd and a fishy odor in litmus milk in about twenty-four hours. Soon a digested layer appeared at the surface and this deepened with age until after six or seven days there was only a small mass of sedimented curd and this slowly decreased with continued incubation. The fishy odor was pronounced throughout the holding period. At 37°C. there was a definite but rather soft curd in twenty-four hours. The curd showed some tendency to whey off and to shrink but even in old cultures the lower half of each tube was still filled with a mass of curd. The fishy odor seemed to be less pronounced than at room temperature. A very few gas bubbles were noted at both room temperature and 37°C. Limiting the oxygen supply by covering inoculated milk with nujol resulted in a slower change at both temperatures.

Determinations at various intervals showed that acid production was more rapid and reached higher values at room temperature than at 37°C., although the final acidities were low in either case. When nujol was used to limit the oxygen supply, the acid development was always slower. The increase in the soluble nitrogen was more rapid and reached higher values at room temperature than at 37°C.; this is what would be expected from the appearance of milk cultures at the two temperatures.

The decrease in the numbers of organisms following the increase apparently began sooner at 37°C. than at room temperature.

The striking difference between the cultures of Bac. ichthyosmius at the two temperatures was the more definite coagulation and less complete digestion at 37°C. than at room temperature.

An enzyme preparation was made by the method used with Ps. fluorescens and when added to milk it caused a digestion without definite curd formation in about three days at either temperature. Microscopic examinations and transfers to agar slopes showed that the digested milk was sterile.

[2] Although incorrect, the original designation is retained. Bergey's designation, *Escherichia ichthyosmia*, is evidently also incorrect. The organism probably belongs to the genus *Proteus*.

[3] Agr. Expt. Sta., Iowa State Col. Res. Bul. 38, 1917.

TRIALS WITH ADDITIONAL ENZYME PREPARATIONS

A number of attempts were made to secure enzyme preparations from various proteolytic organisms that produced rapid changes in milk. The usual procedure followed was to grow milk cultures for several days, add an excess of $CHCl_3$, cork tightly and then shake frequently. The clear liquid collecting at the top was tried out for its effect on sterile milk in the proportion of one to ten, usually at both room temperature and 37°C. The organisms used were two cultures of Staph. cremoris-viscosi, two of Bac. ichthyosmius, one of Ps. fluorescens and one of Strep. liquefaciens, and a number of preparations were made with each. Agar slope cultures were regularly used to establish the sterility of the mixtures of milk and the enzyme materials.

The preparations secured with the two cultures of Staph. cremoris-viscosi and the one culture of Strep. liquefaciens all failed to produce a change when added to sterile milk. Those secured with the two cultures of Bac. ichthyosmius and the one culture of Ps. fluorescens were quite active.

With the enzyme preparations made from the cultures of Bac. ichthyosmius the general change in sterile milk was a digestion and coagulation. In general the action was more rapid and the coagulation more conspicuous at 37°C. than at room temperature, although the difference in the changes produced was not striking and was not as pronounced as the difference between the changes secured when Bac. ichthyosmius was grown in milk at the two temperatures. About six hours was the shortest time in which a definite change was noted in the appearance of the milk to which one of the preparations had been added.

The enzyme preparations secured from the culture of Ps. fluorescens also caused a coagulation and digestion in sterile milk; they seemed to be quite active at 37°C. but at room temperature did not produce a definite change. In general coagulation seemed to be more conspicuous than in milk in which the organism was growing. About two days was the shortest period in which a definite change was produced.

After holding about sixteen months all the preparations seemed to be less active than when they were first prepared.

DISCUSSION OF RESULTS

From the results given it is evident that with certain organisms the type of change produced in milk at room temperature may be different than that produced at 37°C. The greatest difference noted was with certain of the proteolytic organisms and involved the formation of a more definite curd at 37°C. than at room temperature; there was also a difference with the gas forming lactic acid organisms but with the true lactic acid forms the type of change was not influenced by the temperature, although the rate was. This effect of temperature is of importance from the standpoint of the descriptions of organisms and suggests that in giving the changes produced in milk the temperature should be stated.

It seems probable that because of its complexity milk might show a greater difference in the changes produced at various temperatures than most media. However, certain results indicate a pronounced temperature effect in the changes occurring in other media; for example, Hammer[4] found that Bac. ichthyosmius produced acid in salicin bouillon at room temperature, while at 37°C. an alkaline reaction developed.

There are various possibilities in connection with the cause of a difference in the changes produced at different temperatures. One explanation is a variation in the effect of the products of bacterial growth. This seems a probability with such organisms as the aerobacter types studied, where the acid is just about enough to cause coagulation; at the higher temperature the curd may be firmed up more than at the lower temperature, due to the combined effect of the acid and the heat, and the firm curd would more definitely show breaks due to the rising of gas bubbles than would the soft curd. Another possible explanation is a difference in the products of bacterial growth at the two temperatures. This involves whether or not the sweet curdling and the digestion are due to the same enzyme. The results obtained give no definite evidence on this point; it is just as probable that one enzyme might show a different effect at two temperatures as that two enzymes would be produced in different proportions.

[4] Agr. Expt. Sta., Iowa State Col. Res. Bul. 38, 1917.

SUMMARY

Comparisons were made of the changes produced in milk at room temperature and at 37°C. by various organisms. With certain species the temperature seemed to influence only the rate of change, while with others it also influenced the type. The changes produced at the two temperatures showed the greatest difference with certain of the proteolytic types, although other organisms also showed some differences; with these proteolytic organisms coagulation was much more conspicuous at 37°C. than at room temperature. The type of change was not influenced by the temperature with the true lactic acid organisms, although with certain of them the rate was greatly influenced.

The results suggest the necessity of giving definite information as to the temperature used when the changes produced in milk are recorded in the descriptions of organisms.

ABSTRACTS OF SOME PAPERS PRESENTED AT THE ANNUAL MEETING[1]

The Hydrogen Ion Concentration of Cold Storage Butters. E. H. PARFITT, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

The butters entered in the Butter Storage Contest at the National Dairy Show at Detroit in 1926 were tested to determine the hydrogen ion concentration when entering storage and when leaving storage. The storage period was three months. Butters increased in hydrogen concentration from average pH 6.13 to 6.43. As the score decreased in storage, the pH decreased excepting butters scoring over 94 and under 89. The butters which showed large numbers of proteolytic organisms increased in pH more than the butters low in proteolytic types. Butters with an alkaline flavor were acid, but increased more in pH than did butters not having an alkaline flavor. Butters containing starters varied the least in pH. The pH was determined colorimetrically.

Methods of Adding Sugar to the Ice Cream Mix.[2] W. H. MARTIN, Dairy Department, Kansas State Agricultural College, Manhattan, Kansas.

The purpose of this study was to compare, the common practice of adding sugar to the ice cream mix before homogenization, with another method of adding sugar after homogenization. Forty-four mixes were prepared and processed. Viscosity determinations were made, microphotographs of the fat dispersion taken, the rate of freezing and amount of overrun recorded. The body and texture of the ice cream was judged by different individuals

[1] The following abstracts are from papers read at the June meeting of the American Dairy Science Association held at East Lansing, Michigan, June 22 and 23, 1927.—EDITOR.

[2] From a thesis—Sugar in Ice Cream, submitted by Kenneth Miller Renner in partial fulfillment of the requirements for the degree of Master of Science, Kansas State Agricultural College, 1927.

and by allowing the sample to be exposed to room temperature and the rate of melting observed.

The addition of sugar to the ice cream mixes before homogenization increased the viscosity to a greater extent than did the addition of the sugar after homogenization. The fat, as indicated by the micro-photographs, was more highly dispersed in the mixes homogenized without the sugar than in the case of the mix homogenized with the sugar present. Sugar added to the mix after homogenization increased the ease of obtaining overrun. The resistance of the ice cream to melting at room temperature was decreased by the addition of sugar to the mix after homogenization. The method of adding the sugar had practically no effect on the body and texture of the finished ice cream.

Recent Results Concerning Vitamin B Requirements for Calves.

S. I. Bechdel, H. E. Honeywell, R. A. Dutcher and M. H. Knutsen, Pennsylvania State College, State College, Pennsylvania.

Investigations on the vitamin B requirement of calves were started at the University of Minnesota in 1922. Three years ago this investigation was transferred to the Pennsylvania State College where it is still in progress.

The results of the work up to April, 1926, as published in the September, 1926, issue of the Journal of Dairy Science, gave definite evidence that calves, unlike any other species of animal yet studied, will grow normally to maturity and produce normal offspring, on a ration that carries an insufficient amount of vitamin B to support growth and well-being in rats. In this report we stated that the deportment of the experimental calves could be explained only on the basis of vitamin B synthesis by bacteria and other microörganisms in the digestive tract.

The milk from three of the experimental heifers that were fed continuously on the deficient ration for over two years was tested and found to carry as much vitamin B as milk from cows receiving a good winter ration.

In order to make a study of the possible synthesis of vitamin B in the digestive tract, a permanent opening or fistula was made

into the rumen, through the left side of one of the experimental heifers to facilitate the removal of samples of fermented feed for study. Alcoholic extracts, made from the fermented rumen contents have given very positive evidence of the presence of the vitamin B growth factor.

A study of the bacterial flora revealed the presence of an organism which was predominating to the extent of about 90 per cent. Classification studies to date indicate it to belong to the genus flavo bacterium. The species does not appear in any classification. This organism was grown in large quantities on the surface of vitamin B free nutrient agar. The bacterial growth was washed from the media with sterile water and the suspension evaporated at a temperature of about 45°C. The dried bacterial cells were fed to young rats as a supplement to a vitamin B free synthetic ration. Results to date have given very positive evidence that the bacterial cells are highly potent in the vitamin B growth factor.

In the course of a few weeks we hope to have our data sufficiently augmented to publish a technical paper concluding that cattle, unlike any species of animal yet studied, have the ability to synthesize their own needed supply of vitamin B through bacterial synthesis in the rumen.

The Food Value of Milk as Affected by Rations. The Effect of High and Low Protein Rations. (*Progress Report.*) W. E. KRAUSS, Ohio Agricultural Experiment Station, Wooster, Ohio.

It was found at the Ohio Agricultural Experiment Station that when cows were fed rations with nutritive ratios of 1:4 and 1:9 production was maintained and the chemical composition of the milk remained unchanged. In order to arrive at the limits of protein feeding rations of wider diversity, nutritive ratios of 1:2 and 1:13 were fed to two groups of three cows each and a study of the nutritive value and chemical composition of the milk produced on these rations begun.

A slightly greater amount of vitamin A, in keeping with the amount furnished in the feed, was found in the milk of the high

protein cows. This difference was not great enough to be of significance in rating the quality of the milk.

An exclusive milk diet of milk from the high protein cows caused the death of rats in a very short time. Some toxic substance is thought to have been a contributing factor in bringing about such early death since the iron content of the milk was found to be practically the same as that of milk, which when fed as the only source of food, enabled rats to live much longer.

When milk from the high protein cows was fed as a supplement to a basal ration no harmful results were observed in rats and calves.

There was some indication that milk from cows fed a ration extremely low in protein is lower in nitrogenous constituents and ash and higher in lactose than that from cows fed a ration extremely high in protein.

Regarding High and Low Protein Feeding Experiment. (*Progress report.*) A. E. PERKINS, Ohio Agricultural College Experiment Station, Wooster, Ohio.

Previous work as reported in Bulletin 389, Ohio Agricultural Experiment Station had shown reasonably satisfactory results with rations ranging from 1:4 to 1:11 in nutritive ratio.

This paper reported the progress to date in the use of rations of still greater extremes, 1:2 and 1:13. This is as far in either direction as it seems possible to go with feeds commonly available on the market, if the rations are kept approximately normal in other respects.

Both extreme rations are undesirable, failing to maintain the cows in proper condition and giving smaller production than the intermediate rations.

A tendency for the cows to go off feed and failure to consume liberally of the rations has featured this phase of the work and may be responsible for the poor condition and production.

There are strong indications that breeding difficulties are developing.

It is felt that the limits of successful high and low protein feeding have been reached.

The Possibility of Producing Iodized Milk. C. F. MONROE, Ohio Agricultural Experiment Station, Wooster, Ohio.

If the feeding of iodine to cows leads to the production of iodized milk there must be a large amount of milk sold in Ohio that is relatively rich in iodine. Some of this milk is produced in dairies where iodized milk is desired and the product is specially advertized and sold as "iodized milk." In other dairies the iodized milk is merely incidental to the feeding and administering of iodine to pregnant cows in order to prevent goiter in the new born calf. Many mineral mixtures and proprietary feeds contain added iodine. Therefore, whether or not we are in accord with the therapeutic principle of iodized milk, it is a question that is already with us, that is, if iodine is secreted in the milk from cows receiving iodine.

As yet the present work at the Ohio Station has not advanced to such a stage as to warrant any final conclusions. Samples of milk from various cows which have not received iodine have been examined and we have been unable to find any iodine present. We do not claim this milk to be entirely free from iodine, but we are sure that the iodine content was less than 1 part in 100 million. On the other hand, we have been able to find iodine in the milk of cows which received iodine in the form of potassium iodide, the amount varying between 1 part in 100 million to 1 part in 10 million.

The rate of feeding has been 0.1 gram of potassium iodide daily, or approximately 0.08 gram of iodine. At first the potassium iodide was mixed with the salt and this feed mixed with grain. Later we found it more convenient to make a solution of potassium iodide of such a strength that 25 cc. of solution contains 0.1 gram of potassium iodide. This amount constitutes the daily dose, and is sprinkled over the dry grain in the evening.

The Adaptation of the MacDonald Process for the Removal of Onion Flavor and Odor in Milk to Creamery Practice. C. ELMER WYLIE, University of Tennessee.

The MacDonald process for removing onion flavor and odor from milk was discovered by Dr. Margaret B. MacDonald, of the

Tennessee Agricultural Experiment Station.[3,4] Briefly, the process, as determined with small quantities of milk, consists in the mixing of mineral oil with onion milk, which absorbs the onion flavor (allyl sulfide); the separation of the oil from the milk by gravity and filtration; washing the oil; and driving the onion flavor off and sterilizing the oil by heat or live steam. The oil is then ready for use again.

The purpose of this paper is to show the preliminary adaptation of this process to creamery practice and equipment.

A 40-gallon pasteurizing tank of the Sharples Emulsifying unit was used for the experiments at the University of Tennessee Creamery. Seven gallons of onion milk was placed in the tank, and five pints of Lilly Colorless Mineral Oil was added. The agitator was started at a *reduced* speed, and the steam turned on in the water of the double jacket in order to heat the milk. The milk was agitated, and was heated to 115°F. It required about 12 minutes to raise the temperature to that point. The agitator was stopped several times to allow the oil to rise to the top and to prevent too much agitation. The milk was left undisturbed for three minutes. After the oil had risen a sample was drawn until no oil appeared in the milk. This sample was poured back into the tank and another sample drawn to taste for onion. There was little if any evidence of onion flavor or odor in the milk. The milk was then drawn off through a cotton pad strainer into a milk can. Under the strainer was placed a special oil saver. This was designed to keep the oil from coming into contact with the cotton filter pad by keeping a layer of milk above the cotton pad. The oil was then drawn out into a can and the tank flushed out with cold water into the same can. The milk was poured back into the tank and the entire process repeated. The milk was then cooled and placed in cold storage. The taste of the milk at this stage showed no onion flavor or odor.

All of the oil was poured into the tank and first washed with cold water to remove the milk, and then with a 10 per cent solution of washing soda. This wash water was drained off, and the

[3] Circular No. 14, Tennessee Experiment Station.

[4] Journal of Home Economics, Vol. 19, No. 2, February, 1927.

oil was washed twice with fresh water in amounts large enough for the agitator to work. Live steam was turned directly into the oil until it reached a temperature of 180°F. This continued until all onion flavor and odor was driven off and the oil sterilized. The oil and water were then cooled in the tank by running cold water into the double jacket. The oil and water were drawn off into a glass bottle equipped for drawing the water off the oil, and the oil was then ready to use again.

The oil which sticks to the vessels was washed out of the tanks and strainer with a 10 per cent solution of strong alkali. Trials were made with thin cream, which gave similar results, the oil and cream being used in equal amounts for each treatment. The following table shows the results of one of the trials with milk.

	Two treatments	
	Original	Treated
1. Milk, pounds	59	58.5 recovered
2. Milk temperature	75°F.	115°F.
3. Oil temperature	Room temperature	115°F.
4. Lilly Oil, pounds	9	8.8 recovered
5. Fat, per cent	3.4	3.4
6. Bacteria per cubic centimeter	114,000	62,000
7. Taste of milk	Onion	No onion
8. Milk recovered, per cent		99.1
9. Oil recovered, per cent		97.7

A Statistical Study of the Babcock Test. D. H. NELSON, Division of Dairy Industry, University of California.

Some two thousand tests were made of samples of normal unpreserved milk. The test bottles and pipettes were re-calibrated and no tolerance allowed. All results in which the fat columns were not amber colored, translucent and free from visible suspended particles were discarded. Independent readings were made by members of the Dairy Industry Division who were instructed to estimate readings to the nearest hundredth per cent.

The probable error of reading the test is ± 0.02 with a possible variation between different readers of 0.10 per cent. Greater

variations were observed when the fat columns were not amber colored, translucent and free from visible suspended particles. The probable error of pipetting the sample is completely overshadowed by the error of reading the test. The probable error of the Babcock Method under favorable conditions is ± 0.02 which is due mainly to the method of reading. The Babcock Test has a wide variability which is affected by the color and clearness of the fat column as well as the difficulty of reading the meniscuses.

The fat content of the milk has no appreciable effect on the probable error of pipetting the sample or of the method.

On each of six samples of milk forty-four tests were made by the Babcock Method and sixteen tests were made by the Mojonnier Method. The averages of the two methods on each sample were found to agree within the probable error of the Babcock Method.

Opportunities for Dairy Economic Research. ROY C. POTTS, Chairman Committee on Economic Phases of the Dairy Industry, Department of Agriculture, Washington, D. C.

A paper was presented by Mr. Potts on the above subject in which he discussed some of the opportunities and needs for dairy economic research, and presented good reasons for the organization of a Dairy Economic Section of the Association.

The farm value of dairy production amounts to over two and one-quarter billions of dollars annually. The dairy industry is complex by the very nature of its product, which reaches consumers in the form of numerous manufactured products. The dairy industry must be conducted on a sound economic basis if it is to be permanently successful. The marketing and distribution of dairy products must be conducted in accordance with sound business principles and methods. Economists in our agricultural colleges and universities studying the economic phases of the industry, need the close contact that this organization can give them. They need the help of the Departments of Dairy Industry or Dairy Husbandry in our colleges in planning their investigations. A Dairy Economic Section of this Association would afford an opportunity for the dairy economist and the

dairy scientist or technician, to come closer into coöperation with one another in a way that should be helpful to all.

The dairy industry from an economic standpoint is not a fixed and stationary object. Instead it is a rapidly changing, growing, developing business institution which is governed by the wants and desires of nearly one hundred and twenty millions of people. It is one thing today, another tomorrow. Constantly it is undergoing evolutionary change in accordance with economic law.

The economic problems of the dairy industry know no bounds such as are determined and fixed by state lines. Therefore, the study of many of the economic problems of the dairy industry must be as wide as the industry which suggests the need of much coördination of work among research agencies throughout the industry.

If this Association is to serve the dairy industry in a real scientific and practical way as a fact finding and fact disseminating institution, it must coördinate its forces with the forces of other institutions and agencies to the end that it is able to render the largest service to the industry.

I like to think of our economic research in dairying from the standpoint of applied economics and yet that should hardly be necessary, for if our economic research lacks practical application it is not practical economics. At this stage we ought not to waste much time on things that are not practical.

SPECIAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

A special meeting of the American Dairy Science Association was held at Gayoso Hotel, Memphis, Tennessee, October 18, 1927 under the auspices of the Southern Division. A very fine program of special interest to southern dairy workers was given. Among the speakers were: C. W. Larson, Chief, Bureau of Dairy Industry, Washington, D. C.; Dr. Bradford Knapp, President, Oklahoma Agricultural and Mechanical College; Mr. J. H. McClain, Dr. J. G. McDowell, Mr. J. B. Parker, Mr. T. E. Woodward, Mr. Ernest Kelly, Mr. R. R. Graves, Mr. M. H. Fohrman, and Mr. W. W. Swett, all from the Bureau of Dairy Industry; and J. H. Frandsen, Editor JOURNAL OF DAIRY SCIENCE.

Tuesday evening a splendid banquet was tendered to the members of the students' judging teams, members of the association and friends of the dairy industry. President Morgan of the University of Tennessee gave the principal address. Mr. W. W. Swett, superintendent of the nineteenth annual students' national judging contest announced the awards of the contest in which 32 teams participated. Mr. Wm. White, superintendent of the eleventh annual national contest in judging dairy products announced the awards in that contest in which 14 teams took part.

Much credit for the success of this special meeting is due to the untiring work of President J. S. Moore and Secretary A. C. Baer of the Southern Division.

Regular sessions of the Production Section and the Official Testing Section were also held at this time. Minutes of these meetings follow.

PRODUCTION SECTION

A meeting of the Production Section of the American Dairy Science Association was called to order by Chairman A. C. Rags-

dale at 4:30 p.m., October 18, 1927, in the Gayoso Hotel at Memphis.

The minutes of the previous meeting were read and approved.

W. W. Swett, chairman of the Committee on Methods of Conducting Students Contests in Judging Dairy Cattle gave a brief report.

Chairman Ragsdale raised the question as to whether the regular meeting of the section should not be held at the summer meeting of the association, which has been declared the annual meeting.

Because many members cannot attend the summer sessions Mr. Dice suggested that it might be possible to alternate the regular meeting of the section between the summer meeting and the National Dairy Show meeting.

Mr. Anthony moved that the regular meeting of the Production Section be held at the annual meeting of the association. Second by Mr. Gifford. Motion was passed.

E. L. Anthony of West Virginia University was elected chairman and C. F. Huffman of Michigan State College was elected secretary for 1928.

Meeting adjourned at 5:00 p.m.

H. W. Cave, Secretary.

OFFICIAL TESTING SECTION

Minutes of meeting of Official Testing Section, of the American Dairy Science Association, Gayoso Hotel, Memphis, Tenn., 8:00 p.m., October 17, 1927.

I. Reading and approval of minutes of last meeting.

II. Chairman appointed following nomination committee: Harris of Wisconsin, Dice of North Dakota, and Borland of Pennsylvania.

III. Report of Breeds Relation Committee by M. H. Campbell of Vermont. Before giving formal report, Mr. Campbell called upon Harris of Wisconsin, who reported for the Holstein-Friesian Association, and gave summary of proposed Holstein-Friesian Herd Improvement Registry. Lynn Copeland reported for the American Jersey Cattle Club. He stated that there seemed to be

little demand among Jersey men for a herd test. In reporting for the Ayrshire Breeders' Association, C. T. Conklin stated that there were nearly 2600 Ayrshires on test at the present time, or nearly double the number on test at any previous time, and that 95 per cent of the herds on test were starting their third year.

The following recommendations, as reported by Campbell, were approved:

a. (1) This committee believes that a more accurate production may be obtained by using 12 supervisions per year without preliminary milkings, than by using 6 or 8 supervisions with preliminary milkings. We therefore recommend that 12 supervisions without preliminary milkings be used for herd test or herd improvement production records.

(2) This committee believes that the securing of feed records for the benefit of the owner should not be overlooked in connection with herd improvement work. We, therefore, recommend that the owner shall coöperate with the supervisor in furnishing monthly records of feed consumed by each cow, and such records shall be entered in the owner's record book.

(3) We recommend that the maximum milkings be 40 per day, unless supervisor is authorized by the state superintendent to take a larger number. Two cows may be milked at the same time, provided they are near enough for the supervisor to observe both milkers at one time. The supervisor shall run single tests on each sample.

(4) This committee recommends that records made in connection with cow testing (or herd improvement) associations, in compliance with the rules as herein stated, may be accepted for entry in the herd test registry, provided the reports are O.K.'d by the superintendent within the state.

(5) We recommend that daily milk records for each cow under test be kept by the owner. Such records are to be available at all times for inspection by the supervisor, and shall be furnished to the superintendent upon his request. The supervisor should copy on his monthly reports, milk weights for three days preceding the test.

(6) We recommend that a committee be appointed from the

A. R. sections for the purpose of preparing a uniform blank to be used in reporting herd improvement tests.

(7) We recommend that these rules concerning the supervision of herd improvement tests should be sent to each breed association before the next meeting of their board of directors.

After foregoing recommendations were adopted, Campbell continued report as follows:

b. The Breeds Relations Committee of the American Dairy Science Association held a meeting October 16, 1927. Those present were Professors Harris, Reed, Borland, Dice, Williams, and Campbell. Breed Association representatives present were C. T. Conklin and C. M. Cummings, while Professor Harris represented the Holstein Association.

A brief report was made regarding uniform test report blanks. A new supply of 500,000 blanks and 50,000 cards have just been printed. A sufficient supply was sent to each superintendent to last one year. The remainder were divided among the breed associations.

Professor Dice reported on the rules for official testing. Since last year, the Holstein-Friesian Association has printed a new hand book in which are included the rules adopted by this organization. The following recommendations regarding rules were adopted by the committee:

(1) The committee believes that the rule adopted by the A. G. C. C. on the continuation of the one day test in case of a lost milking, is a good thing, and that this suggestion be made to the other breed associations.

(2) The committee recommends that we approve and authorize the A. G. C. C. to print in their rules, the rule asking a breeder to report to the superintendent of official testing in the state, and to the breed association, when a cow is dropped from test.

(3) In view of the fact that the American Milk Goat Association has accepted our uniform rules for the supervision of official tests, except that a supervisor may test 20 goats daily, this committee recommends that the A. R. section of the A. D. S. A. approve the supervision of official tests on milk goats by the superintendents of official tests for the several states.

(4) The American Dairy Science Association has been criticized to some extent for making uniform rules, but not having them enforced in all states. It must be remembered, however, that this Association has no jurisdiction over the various superintendents of official testing.

(5) This committee wishes, however, to recommend that the secretary of the committee send a letter to each breed association, asking which states are not following out the rules, and another to the state superintendents of official testing, with a copy of the uniform rules, and asking if they are following out the rules of the A. D. S. A. The letter to the breed associations might suggest that the field men help gather information regarding rules used in testing. A second letter should be sent to the Dean or Director of the station where rules are not being followed, pointing out the position of the A. D. S. A. in connection with the testing, and making an effort to have these rules adopted in the state.

(6) A suggestion was made that there was no system of uniform blanks to be used by supervisors in various states in taking the barn records, thus causing an inconvenience in filing where check testing was done. It was therefore recommended that a committee be delegated to study the matter of forms for barn records and the possibility of adopting uniform blanks. This committee should report at the next meeting.

IV. Recommendation passed that suggestion be made to Breed Associations, relative to coöperation in the matter of adopting name for the so called Herd Test or Herd Improvement Plan, now known as the Herd Test Plan by the Ayrshire Breeders' Association, and as the Proposed Herd Improvement Plan by the Holstein-Friesian Association.

V. A. C. Ragsdale of Missouri was elected chairman and G. E. Taylor of Michigan as secretary for 1928.

J. M. FULLER, Secretary.

ANNOUNCEMENT

With the completion of this issue of the JOURNAL OF DAIRY SCIENCE I am glad to turn over the editorial responsibilities to the newly elected editor, Mr. A. C. Dahlberg of Geneva, New York. My wish is that he may have the same whole-hearted support that the American Dairy Science Association has given me during the ten years in which I have had charge of editorial work.

I wish especially to express my appreciation to members of the Editorial Board, both past and present, for their careful and conscientious work in reviewing manuscripts referred to them for criticism. Indeed, much of the success of the JOURNAL is due to the helpful coöperation of members of the Editorial Board.

To the publishers, The Williams & Wilkins Company, who have worked in and out of season to make the JOURNAL mechanically perfect, and who have never failed to meet and adjust the many problems that confront editor and publisher alike, I wish to acknowledge sincere appreciation.

J. H. FRANDSEN.

DAIRY NOTES

Officers of the American Dairy Science Association elected by mail ballot for 1928–1929 are:

President: G. C. White, Storrs, Connecticut.
Vice-President: A. C. Baer, Stillwater, Oklahoma.
Secretary-Treasurer: J. M. Sherman, Ithaca, New York.
Editor: A. C. Dahlberg, Geneva, New York,

The members of the American Dairy Science Association by majority vote have asked the executive committee to create a new section of the association to be known as the Dairy Economic Section. It is expected that members interested in such a section will soon complete the organization and elect officers.

The Executive Committee has decided upon Madison, Wisconsin, as the place for the 1928 summer meeting of the American Dairy Science Association.

The sixth annual meeting of the Eastern Division of the American Dairy Science Association was held at the Clinton Hotel, Springfield, Massachusetts, September 19 and 20 in conjunction with the Eastern States Exposition. The colleges and experiment stations in this division were all well represented at the meeting and on the program. At the annual banquet C. L. Burlingham, Publisher, *The Breeders Gazette*, Chicago, gave the principal address.

J. G. Watson, livestock editor of the New England Homestead made the announcements and presented the awards in the students' livestock judging contest and Wm. White of the Bureau of Dairy Industry, Washington, D. C., made the announcements and awards in the dairy products judging contest.

Mr. L. H. Hempleman, Department of Dairying, University of Idaho, Moscow, Idaho, has applied for a patent on an invention known as "A Mechanical Device for the Rapid Calculation of Balanced Rations." The inventor claims that this device will greatly simplify the matter of computing rations.

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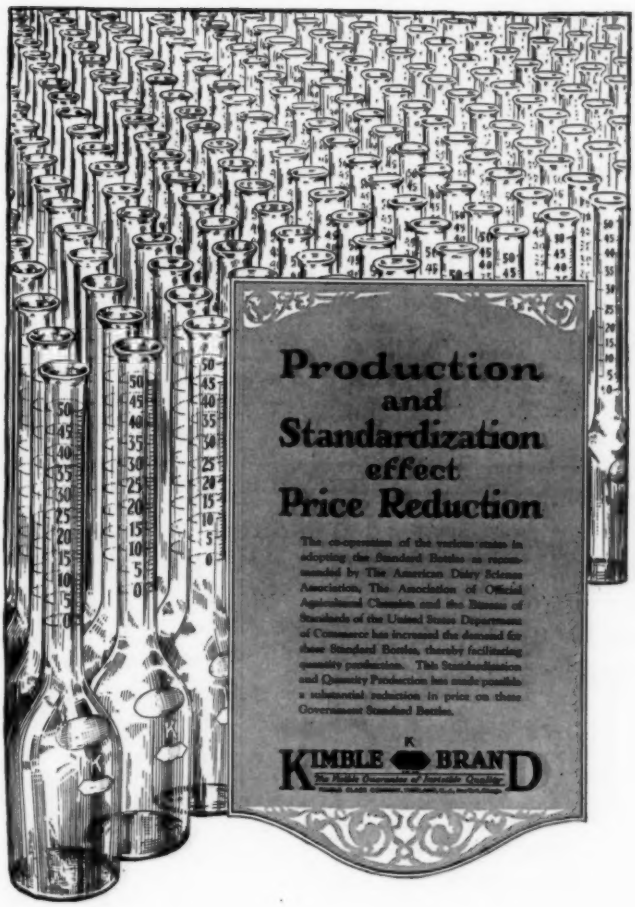
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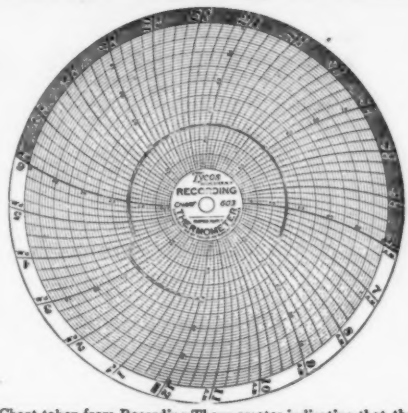

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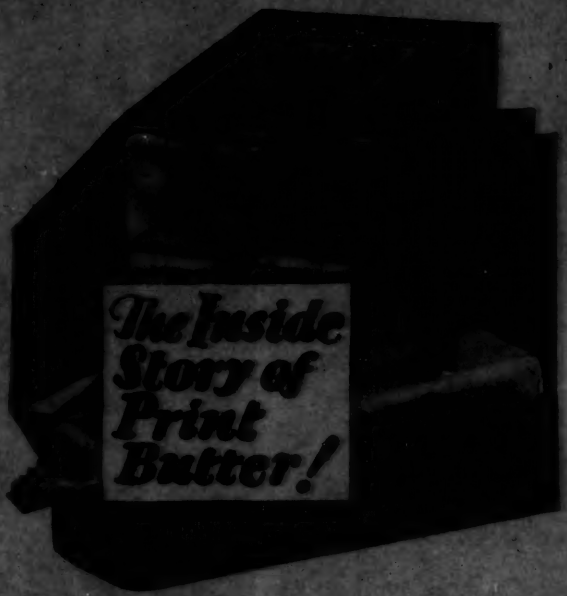

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